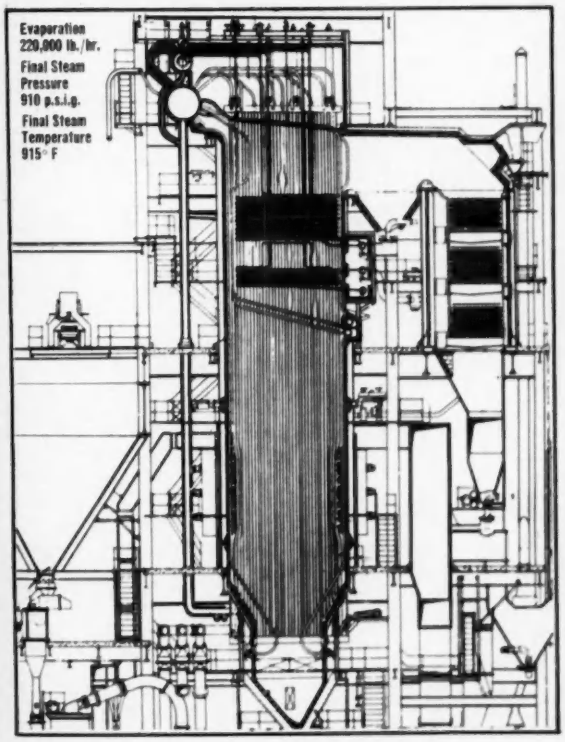
The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIX No. 4 APRIL, 1958

3772A

Steam raising for industry



An example of an installation at a large British paper mill is illustrated here.

IC build boilers to suit the individual steam raising requirements of every industry. Whatever the problem, IC steam generating equipment ensures the best use of fuel resources. Allied equipment covers every requirement from fuel handling to ash disposal.

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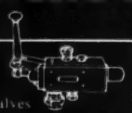
in every industry

Top illustration shows a combined high and low pressure delivery type Mono-Radial Pump. Because of its compactness and suitability for self-contained hydraulic equipment, this type of Mono-Radial Pump was chosen by Messrs. R. Hoe & Crabtree Limited for their 750 Ton Hydraulic Matrix Moulding Press (also shown).

for efficiency fit a

FRASER *MONO-RADIAL HYDRAULIC PUMP*



VALVES

Mono-Radial Control Valves are arranged for one or more hydraulic supplies under manual, remote or power operation.

Every hydraulic pumping need is met by Fraser Pumps. The range includes single pressure, combined high and low pressures and infinitely variable delivery Pumps. Designed for use with all types of machinery, Fraser Pumps give efficient, long and reliable service under the most arduous operating conditions.

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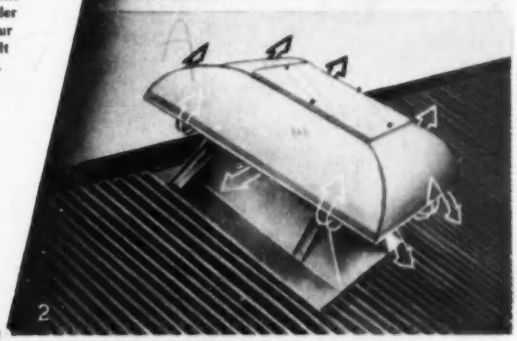

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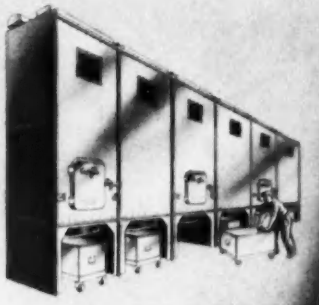

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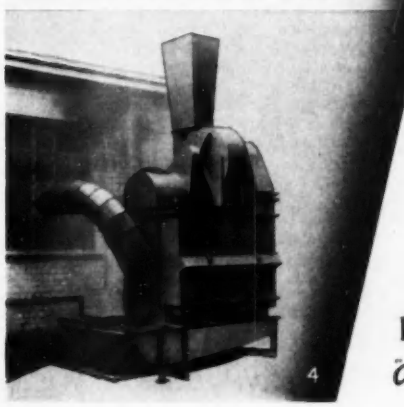

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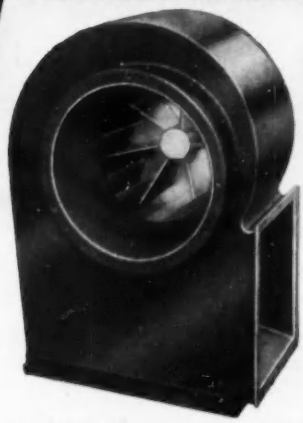

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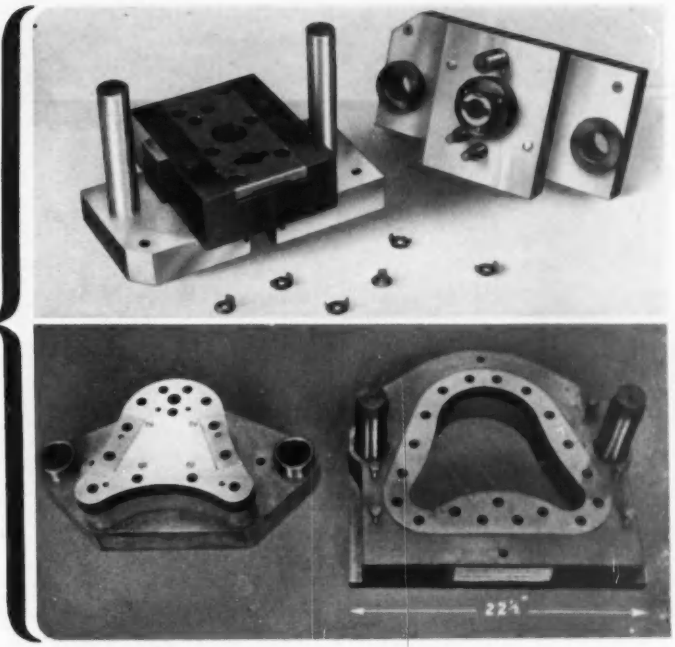

BECAUSE of its high chromium and carbon content, 476 Steel resists wear and is specially suited for exacting punching and forming operations on abrasive materials. It has also considerable toughness, the tool edges standing up to shock applications, such as heavy punching and shearing. The photographs illustrate two contrasting applications. (Top) Three stage press tool for punching and forming clamping washers from brass strip (courtesy, Clarke Chapman & Co. Ltd.). (Bottom) Heavy press tool for blanking hoist bracket in $\frac{1}{8}$ in. thick mild steel (courtesy, Stothert & Pitt Ltd.). 476 is air hardening and machinable in the annealed condition. Applications include blanking dies and punches for sheet brass, copper, zinc, high silicon transformer steels and hard abrasive materials generally ; blanking tools for steel sheet and plate ; blades for flying strip shears and plate shears ; deep drawing dies, cupping dies, forming dies ; sheet metal forming rolls ; circular cutters for strip ; trimmer dies, thread rolling dies ; gauges and other precision tools ; taps, staybolt taps ; brick mould liners ; master hobs for cold hobbing plastic moulds ; cut moulds for plastics.

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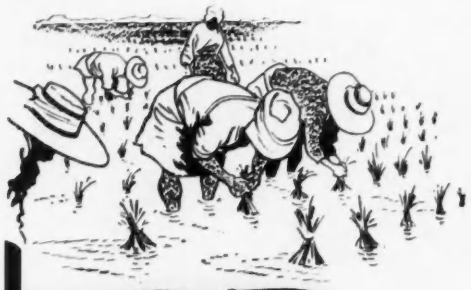

Mirrlees

diesel power for THAILAND

Twenty years ago the need arose to build a port installation on Thailand's main river, the Menam Chao Phya, as close as possible to the capital Bangkok, to provide berthing, warehouses and wharfeside cranes. The initial stage was completed before the war and finality will soon be reached. The nature of the river prevented siting the port in the heart of the city: Bangkok's own electricity needs were rising rapidly; incoming equipment, interrupted by the war, placed higher demands on the port. For all these reasons it was decided that the port should have its own diesel power station. Five years ago, Mirrlees/Brush equipment won a contract for generating sets to meet the present demands and three Mirrlees K6 engines were supplied, running at 428 rpm, driving Brush 575 kW alternators.

These sets with their associated 3.5KV Brush switchgear transformers and auxiliaries are now operating in a very attractive 2 storey power station, having provision for 2 further sets, on what is virtually a swamp, on concrete foundations each supported by fifteen 36 cms. (14 in.) dia. piles 16 m. (52 feet 6 in.) long both vertical and raked.

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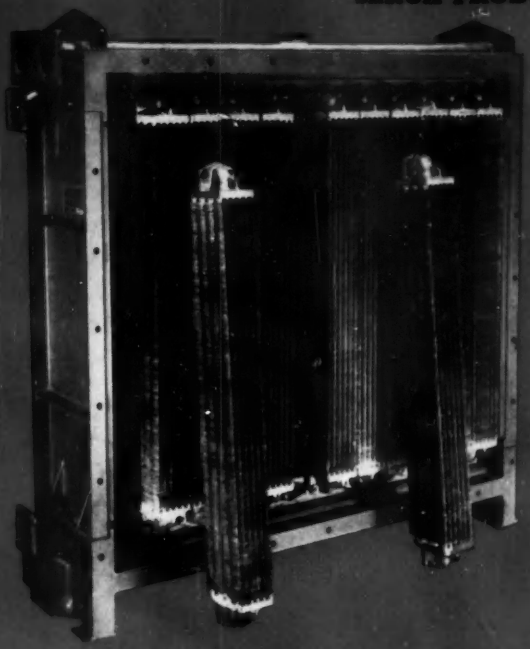

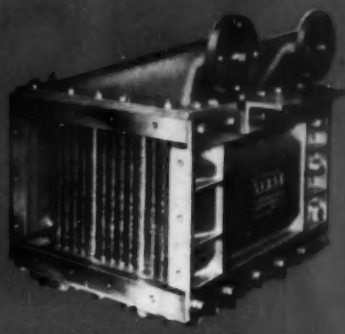

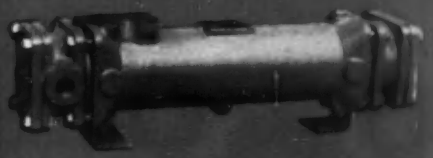

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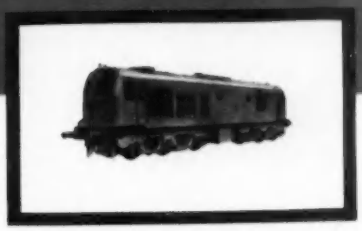

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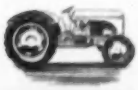

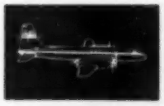

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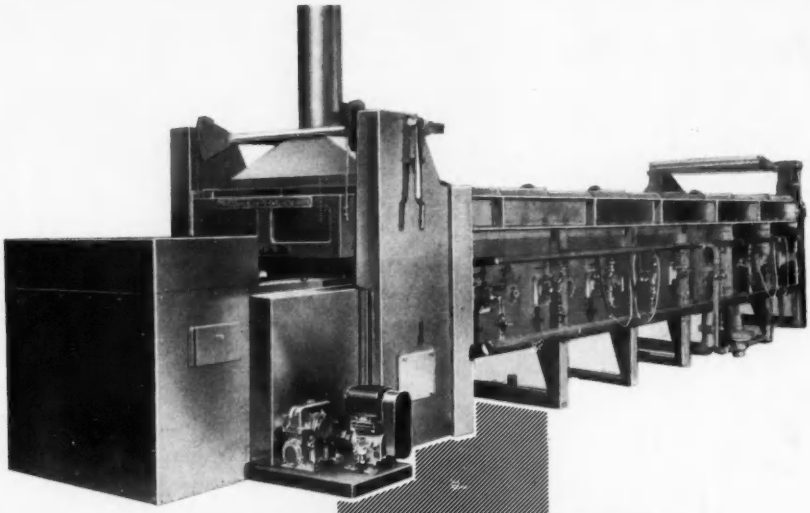


Another Carter Variable Speed Drive

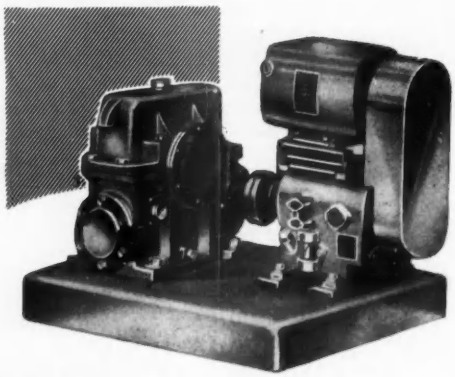
STAND 356

This slow speed drive to a Gas Fired Continuous Tempering Furnace includes a Size F10 Carter Variable Speed Gear.

Built by the Dowson & Mason Gas Plant Co. Ltd., the process speed may be infinitely varied by means of the Carter Gear control, adjustable with the drive running or stationary.

Remote Electrical, Hydraulic, Hand or Lever controls are available with all sizes of Carter Gears.

Specialists for over 20 years in the design, manufacture and industrial application of Hydraulic Variable Speed Gears. For full details of the entire fractional up to 35 horse power range of Carter Variable Speed Drives write for Folder 658.



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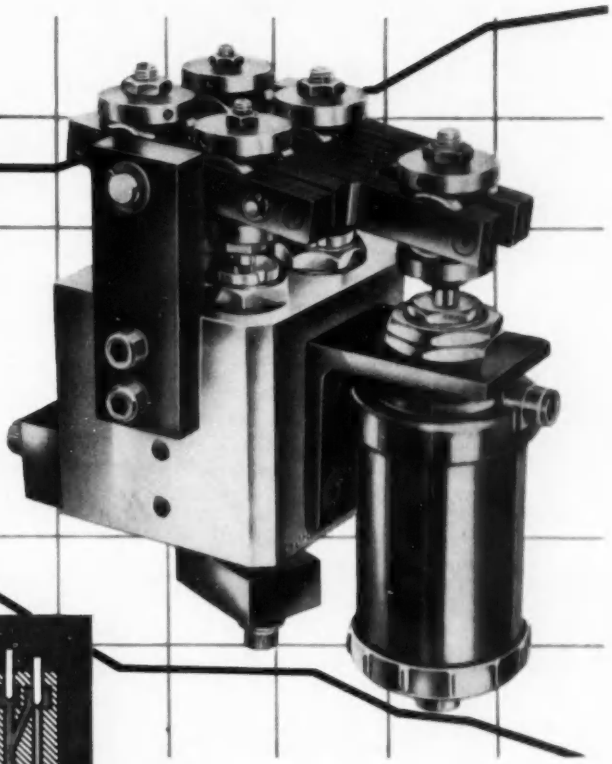

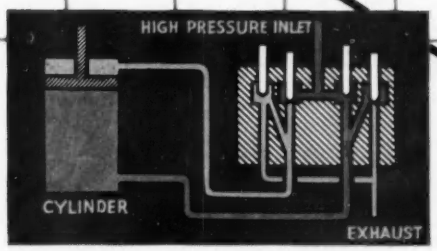

Double-acting cylinder with controllable pressure fluid fed to both ends of cylinder.

Operating in conjunction with timing instruments, Ellison Hydraulic Valves provide Automation with little capital outlay—enabling several hydraulically operated machines to be controlled automatically by a single operator. Further, arrangements can be made for automatic control of machine safety guards to comply with Factory Act regulations. Ellison Valves mark a real step forward in hydraulic practice.

They embody new features to prevent scoring of seats and stems and to ensure trouble-free service with little maintenance.

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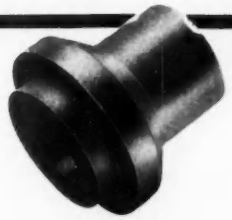

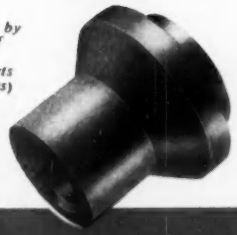

Illustration by courtesy of Aylesbury Turned Parts (True Screws) Ltd.

- Improved finish
- Lower costs
- Increased Machining Efficiency
- Longer Tool Life

KE 40 A.M. is supplied in centreless ground lengths to close tolerance of size, thereby eliminating collet troubles.

KE 40 A.M. will machine almost as easily as Free Cutting Mild Steel.

KE 40 A.M. also gives highest cutting speed combined with long tool life.

Test carried out on a single spindle automatic producing the component illustrated above and using ordinary E.N. 56 A Stainless Iron and K.E. 40 A.M. gave this comparison:—

	E.N. 56 A.	K.E. 40 A.M.
TOOLS	18/4/1 High Speed	18/4/1 High Speed
COOLANT	Straight Cutting Oil	Straight Cutting Oil
PRODUCTION	Completely auto	Completely auto
DRILLING FEED PER REV.	.003"	.003"
FORMING FEED PER REV.	.0008"	.0008"
PART-OFF FEED PER REV.	.0009"	.0009"
FEET PER MINUTE	90	130

This booklet, giving greater detail, is available free on request.

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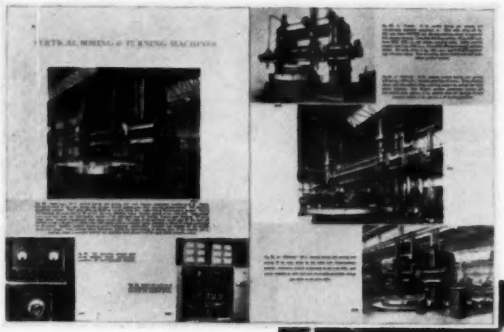
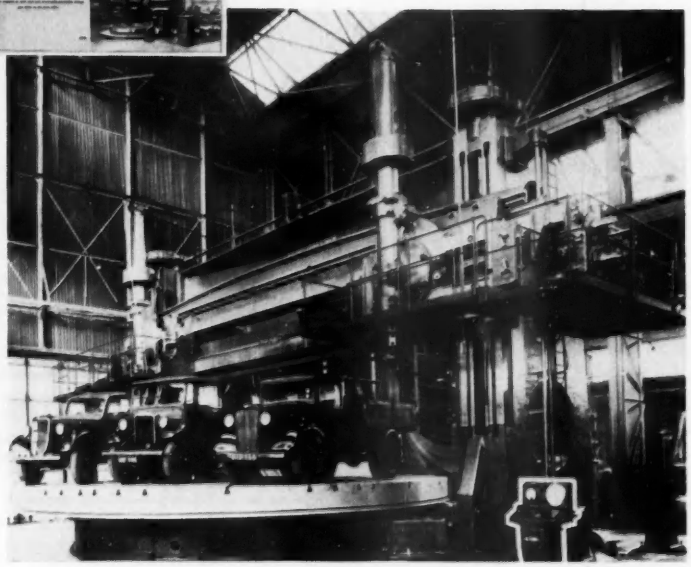
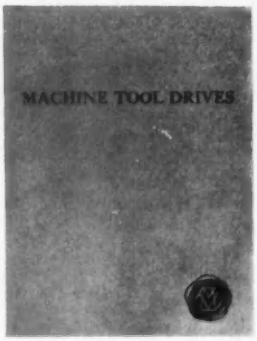




Leading machine tool makers choose METROVICK motors and control gear. This "Richards" 35-ft. capacity vertical boring and turning mill is one of many outstanding examples illustrated in the M-V publication "Machine Tool Drives". The main drive is a 100-h.p. DC variable-speed type Q motor. There are also a 25-h.p. elevating motor and independent 10-h.p. reversing motors for driving the rapid power traverses. Outlined in white is one of the two control desks also supplied by Metropolitan-Vickers.

Metrovick engineers have collaborated in the solution of hundreds of problems relating to the electrical drive and control of machine tools. This wealth of experience is available to all machine tool designers and users, to whom a copy of "Machine Tool Drives" will gladly be forwarded on request.



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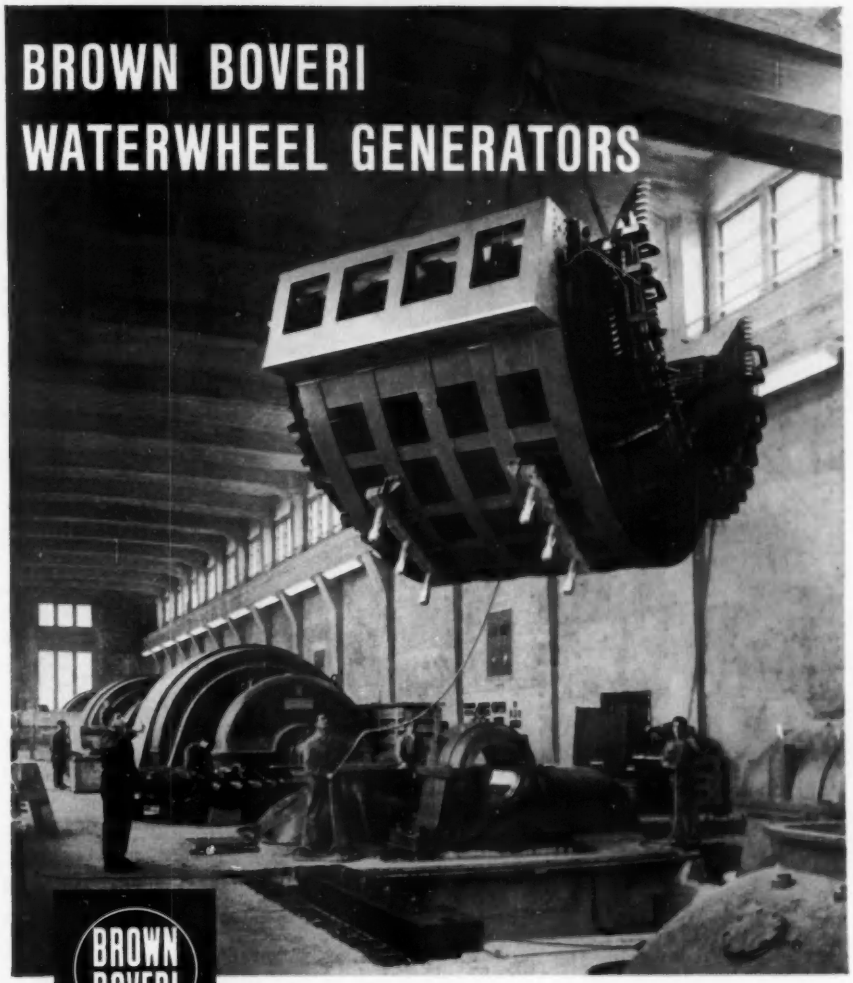
BROWN BOVERI WATERWHEEL GENERATORS



BROWN BOVERI

leaders in the design of high-speed salient-pole waterwheel generators

Brown Boveri supplied the five alternators for Riddes, owned by the Forces Motrices de Mauvoisin S.A., Sion ; with its output of 335 MVA this is the largest hydro-electric plant in Switzerland.

Some large waterwheel generators at present under construction or being installed :

No. of Units	Output kVA	Shaft	Speed r.p.m.	Power Station	Country
1	23 000*	V	1 000	Oberaar	Switzerland
2	20 000	H	1 000	Ernen	Switzerland
3	60 000	V	750	Fionnay	Switzerland
3	29 000	H	750	Motec	Switzerland
1	30 000	V	750	Piottino	Switzerland
3	57 500	V	720/600	Tingambato	Mexico
1	60 000	V	600	Paradela	Portugal
2	45 000	V	600	Hemsil II	Norway
3	17 650	V	600	Neriamangalam	India

* Synchronous motor

BROWN, BOVERI & CO., LTD., BADEN (SWITZERLAND)

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AUTOMATIC TURRET LATHE

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NO REJECTS
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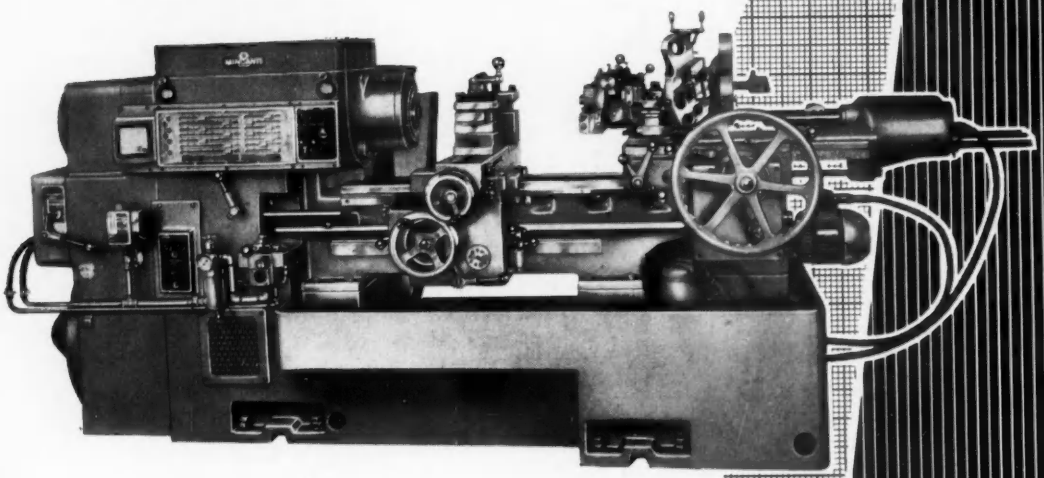
The advantages of Copying Lathes Coupled with those of Multiple Set-up



Standardized spindle end	ASA 6"
Dia. of hole in spindle	2 1/4"
8 Spindle speeds (standard range) r.p.m.	80-1500
8 Spindle speeds (special range) r.p.m.	50-3000
Max. distance from spindle flange to hex. turret	25 5/8"
Max power required	HP 4-8—8
Net weight with standard equipments	lb. 6500

MACHINE TOOL BUILDERS

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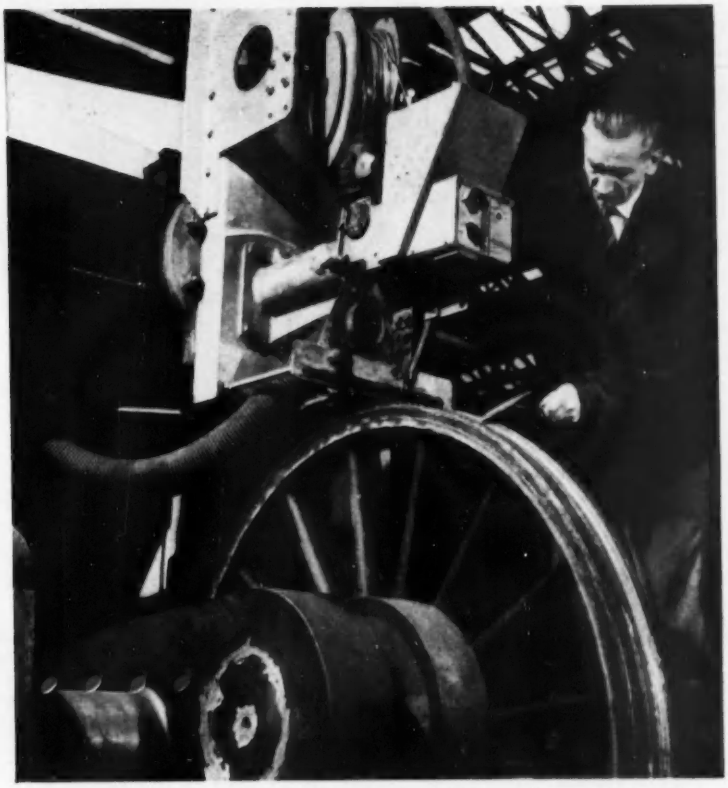
FIRST IN THE FIELD—AND STILL IN THE LEAD

Keeping the wheels turning



Photograph by courtesy of British Railways Magazine (Southern Region)

To maintain smooth running with maximum safety, British Railways Southern Region keep a constant check on the wheels of their locomotives to ensure that they retain a perfect shape and even surface.

At the British Railways (S.R.) Works at Eastleigh, the worn wheel centres are built up to correct dimensions using Lincolnweld Submerged Arc Welding Unit (LAF2) with Lincoln type L60 wire $\frac{1}{16}$" diameter and No. 1 Flux which gives a machinable finish and helps to save expensive replacement costs—cutting down delays too! The large picture above shows the Lincolnweld process in operation.

The Lincolnweld process is speedy (in this application many times faster), highly efficient and easy to control; the arc, as it is constantly shielded from the air by a blanket of flux, not only gives top-quality welds but protects the operator and his work too. The smaller picture shows the front view of the latest Lincolnweld B.11 Fully Automatic Welding Head with special travel carriage for applications where work must remain static. Also available as a stationary unit (Type B.10).

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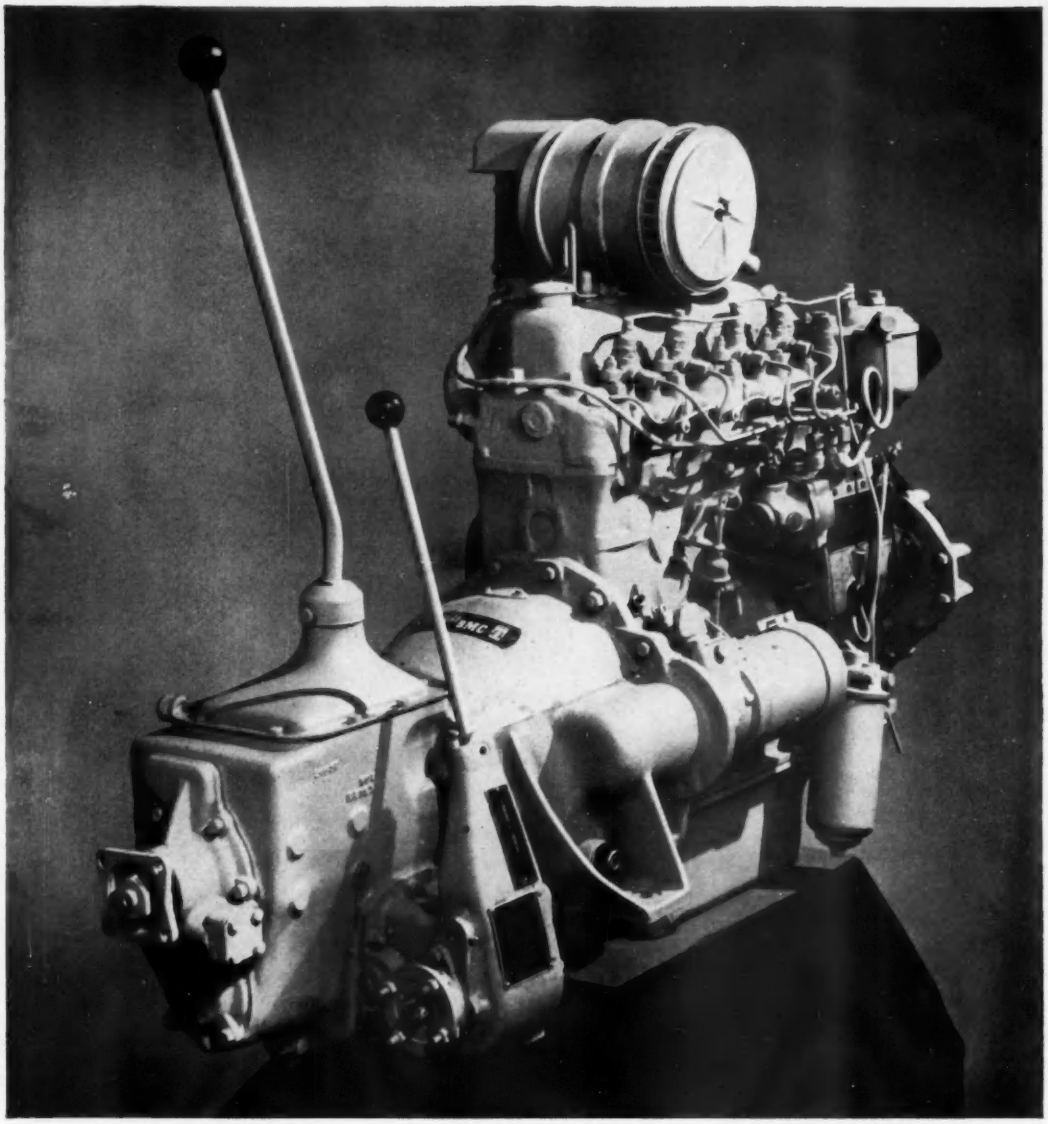

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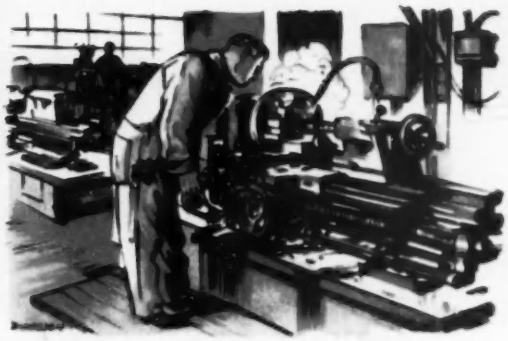
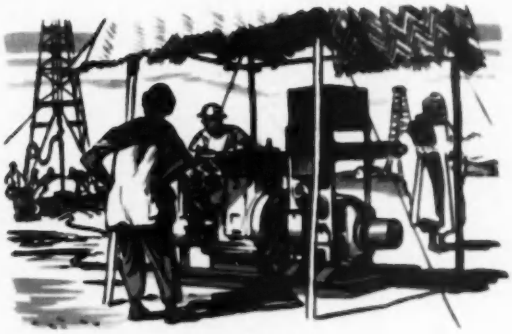


Machine Tools

Contractors' Plant



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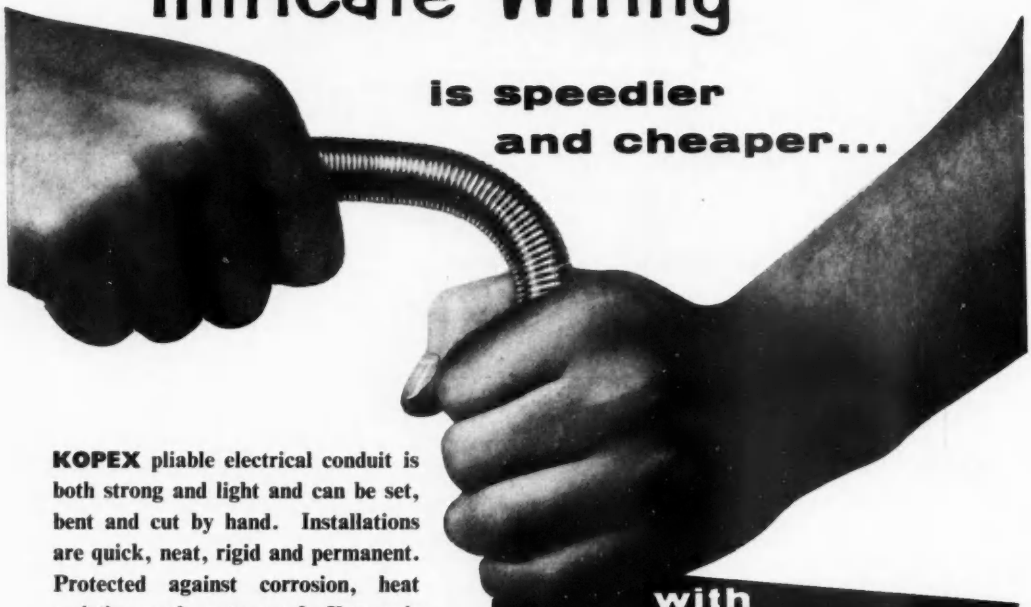

KOPEX pliable electrical conduit is both strong and light and can be set, bent and cut by hand. Installations are quick, neat, rigid and permanent. Protected against corrosion, heat resisting and waterproof, Kopex is the most practical conduit for wiring of machine tools, switchboards, industrial equipment and other factory installations where full protection against corrosion, oil and suds is essential.

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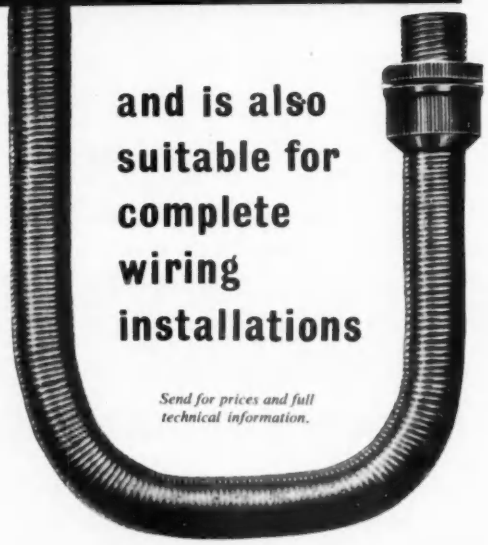

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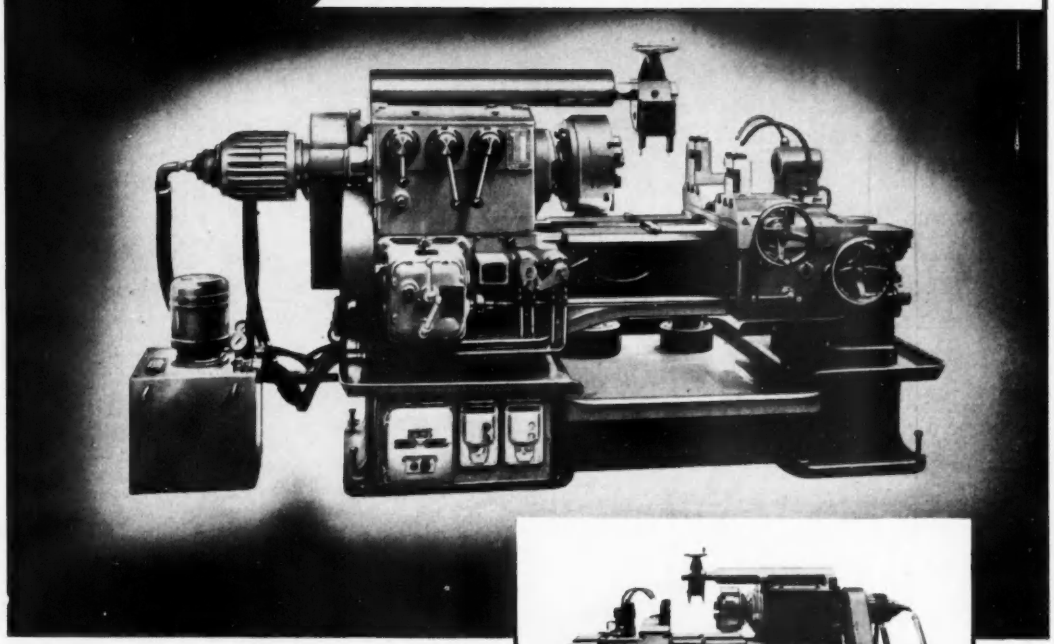
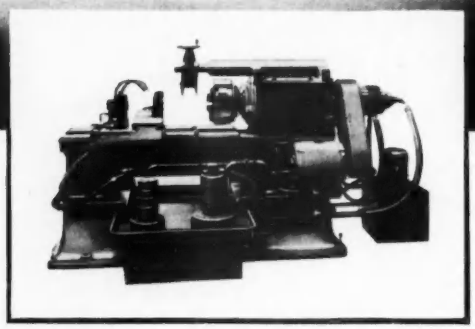
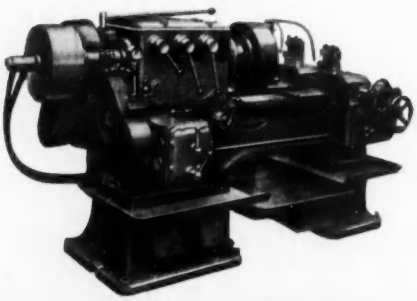
V271

CROWTHORN

8½" CENTRE PARTING-OFF TURNING & BORING LATHE







This lathe is specially designed for the high speed production of such articles as cylinder liners, piston rings, etc., and for the rapid parting-off of ferrous and non-ferrous bar and tube. The specification includes pneumatic or hydraulic chucking equipment, screw operated parting-off toolslide assembly on overhead arm, front and rear tool holders, boring bar holders, self-contained motor drive and electric suds pump. Please write for detailed literature.

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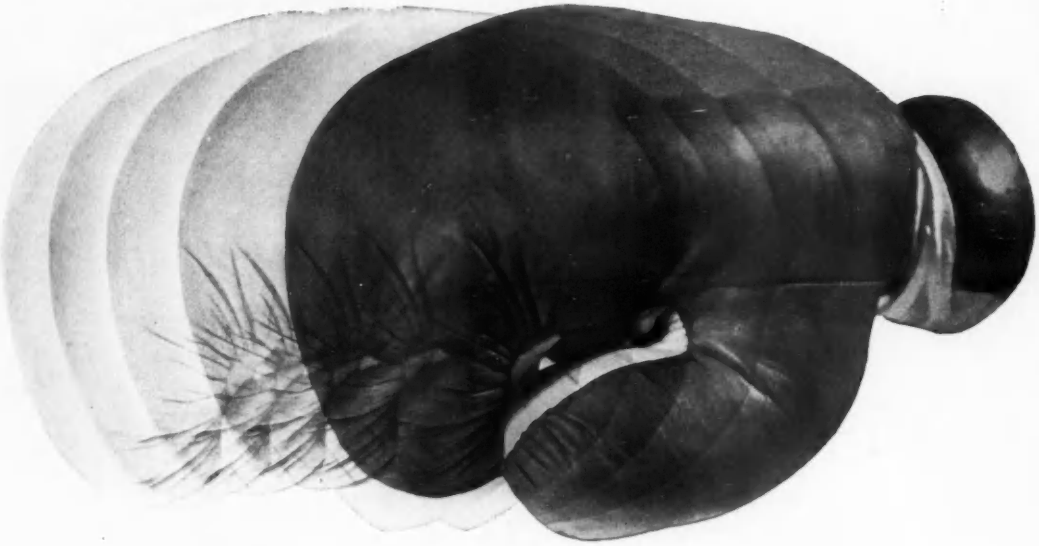
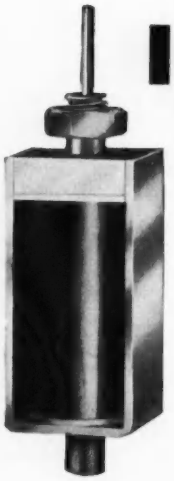


1000 times a minute!



The Varley S.M.O. solenoid is the first of a range of miniature solenoids being developed for the electronic and accounting machine industries.

It can operate about 1000 times a minute through $\frac{1}{8}$ in.

Varley make Solenoids of all shapes and sizes to push or pull anything from ounces to thousands of pounds.

If you need to push, pull, press, prod or punch—*by remote control*—investigate the applications of Varley Solenoids.

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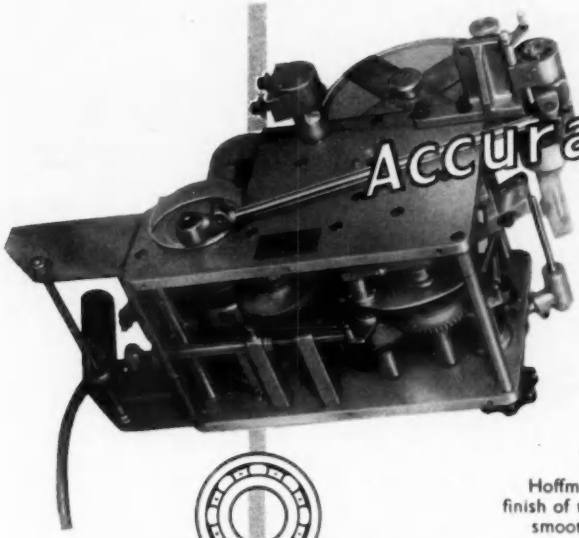

Accurate counting

Vacuumatic Ltd., of Harwich, are producing a range of ingeniously designed mechanical counting machines doing their work in National Banks, Security Printers and Paper Mills throughout the world.

These machines are capable of counting 1,500 sheets of paper a minute; such rapidity and accuracy of motion demand bearings of the highest quality.

Hoffmann Ball Bearings on account of the fine finish of their tracks and rolling elements impart smooth sensitive motion in the counting head as well as on other positions on these machines.

POSITION	BEARING USED
SUCTION BLADE BRACKET	TWO S3 $\frac{7}{8}$" O.D.
HEAD CARRIER	FOUR S1 $\frac{3}{4}$" O.D.
PUSH ROD LINK	ONE 4666 $\frac{1}{4}$" O.D.
WIPER PIN HOUSING	TWO 86 13 m/m O.D.
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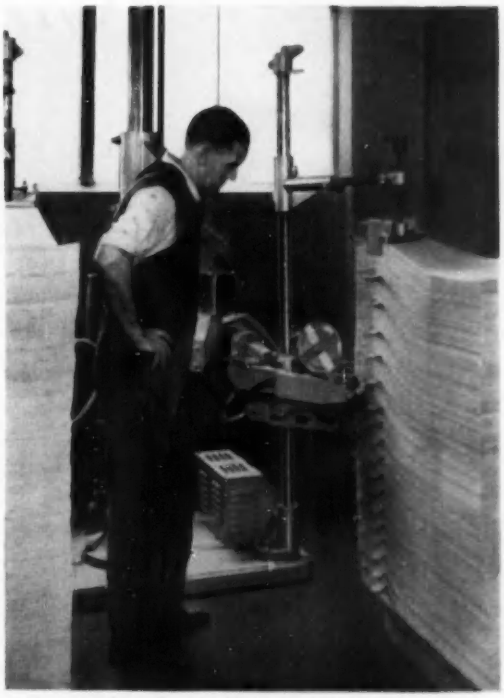
QUADRANT CAM FOLLOWER	ONE 84 9 m/m O.D.

You can *Count* on

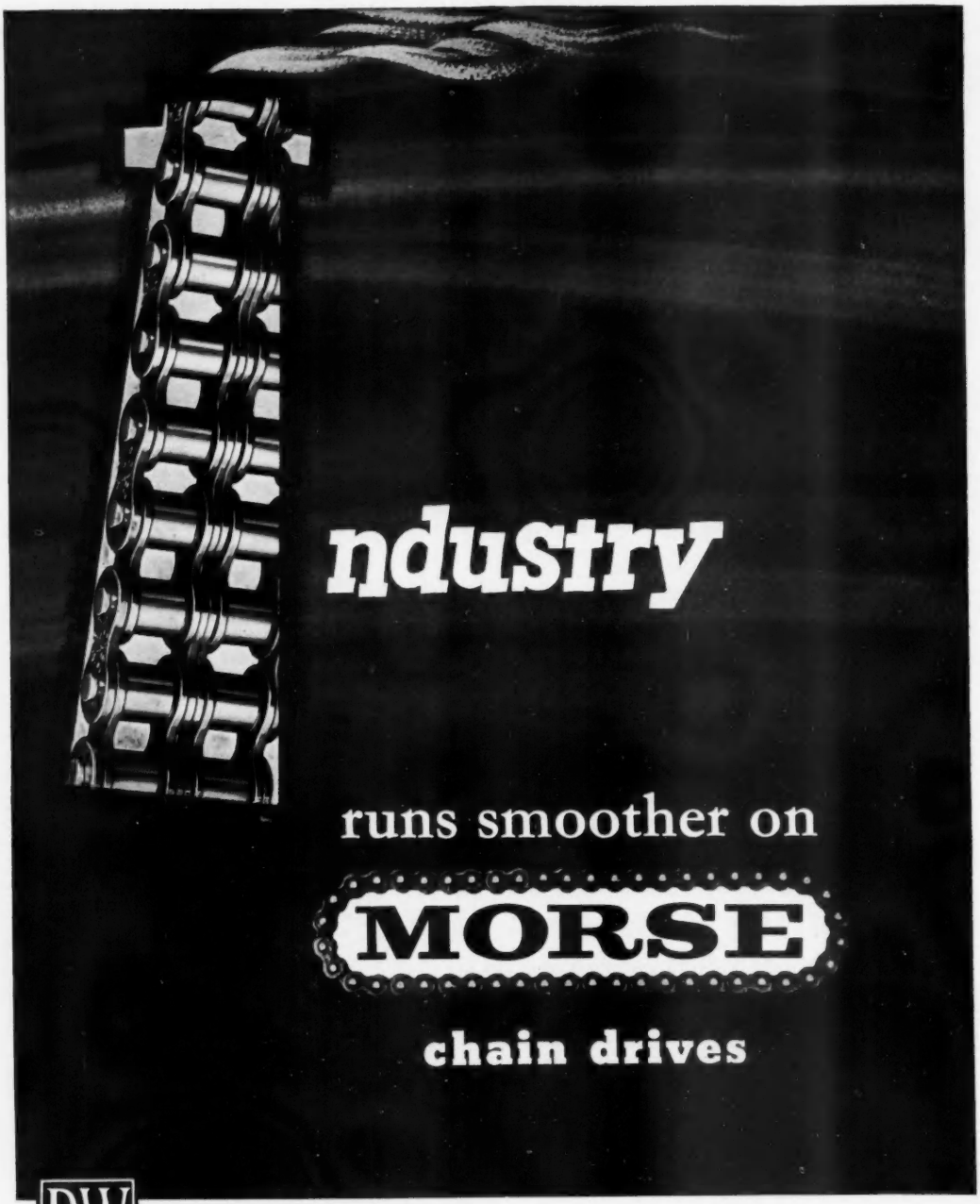
HOFFMANN

MINIATURE BALL BEARINGS



A Vacuumatic Paper Counting Machine in operation.

THE HOFFMANN MANUFACTURING CO., LTD.
CHELMSFORD ESSEX



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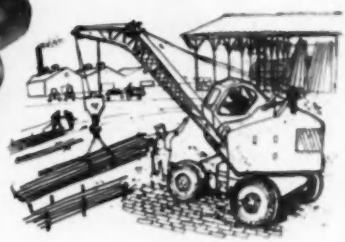

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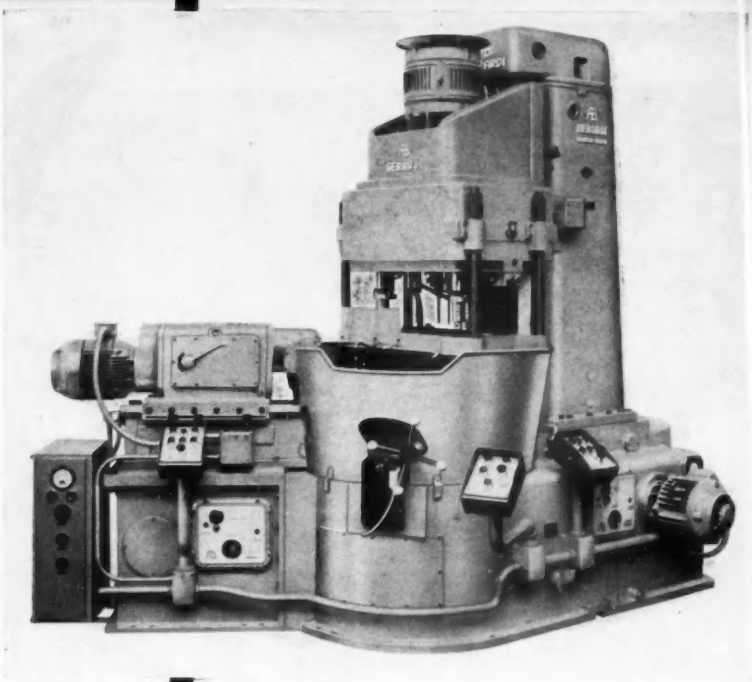
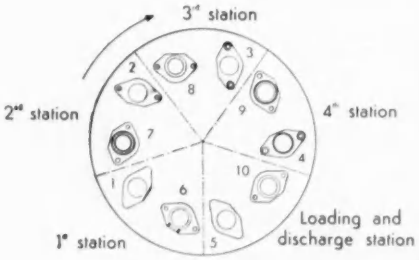
Special combined operation machine with rotary movement of the work pieces.

The head and table movements are hydraulically controlled and are on automatic cycle.





JOB: Bearing housing flange

OPERATIONS :

1st station	: 1 side milling
2nd	: 2 drilling
3rd	: 3 countersinking
4th	: 4 bore and bevel
5th	: 5 turn over job
1st station	: 6 face milling
2nd	: 7 bore out housing
3rd	: 8 bevel off holes
4th	: 9 bevel off housing
5th	: 10 discharge and load job

Actual working time	20 seconds
Dead time	5 seconds
Loading time	0 seconds
Total time for finished job,	25 seconds

Upright Sensitive & Automatic Drills
Multi-spindle heads
Vertical multi-spindle Hydraulic Cycle
Machines, for combined operation
Drilling, Boring, Tapping and Drilling
Horizontal Units (Hydraulic automatic cycle)
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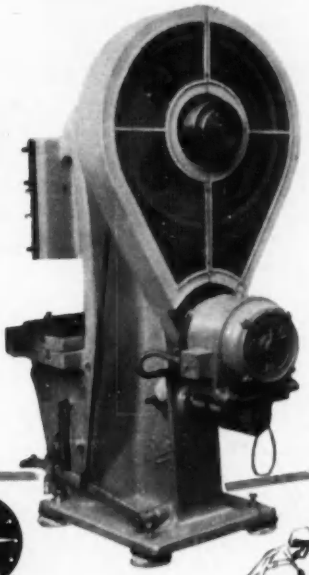
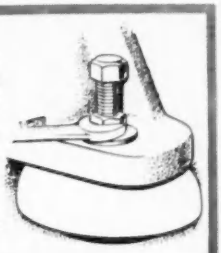
BREAKING INSTALLATION RECORDS WITHOUT BREAKING THE FLOOR



2.0. p.m. Problem. How to get this 50 ton press installed and working with the least possible production delay. How to hold it safe and levelled on an uneven floor riddled with pipe lines. Method chosen: Barrymount Levelling Machine Mounts, as specified by Cementation experts. Time taken:—**two hours ten minutes** This is how:—

3.15 p.m. Press in position. A "Barrymount" Machine Mount goes under each corner—bolted through the mounting hole. There's no grouting in: no rag bolting: no floorbreaking to be done at all.

3.45 p.m. Levelled. "Barrymount" Machine Mounts incorporate their own levelling device. The bolt is turned down and locked at precise levelling—exact to within a thou even on sloping or rough floors. No inexact and time-wasting shimming.



4.10 p.m. Working. No long expensive production delays while the concrete dries out. Directly the press is connected to power, it's ready to work. Its "Barrymount" Machine Mounts act as highly efficient shock and vibration isolators; hold it firm and safe without a sign of "walking".

Where did all this happen?
We've taken a typical problem here ; but it **could** happen in your machine shop. Cases like it crop up almost daily, all over the country, and they're all solved the same way.

"Barrymount" Machine Mounts were introduced here from the U.S. three years ago. Since then their use has spread to thousands of machine shops throughout Britain. Users report installation times cut from days to minutes ; floor space better used ; greater production flexibility and a dramatic decrease in structure-borne vibration and noise.

It's not uncommon for "Barrymount" machine mounts to pay for themselves at installation in terms of production time gained. It's pretty sure that a pilot set on the next machine you install—or move—could show you similar savings, too. If you'd like full technical details, get your secretary to fill in this coupon.

Modern machine tools belong on

MADE IN ENGLAND UNDER LICENCE
BARRY B MOUNT
FROM BARRY CONTROLS INC. OF U.S.A.

LEVELLING MACHINE MOUNTS

Made in steel and oil resistant neoprene to last the life of the machine. Suitable for lathes, grinders, presses, shapers of all makes up to 25 tons deadweight.

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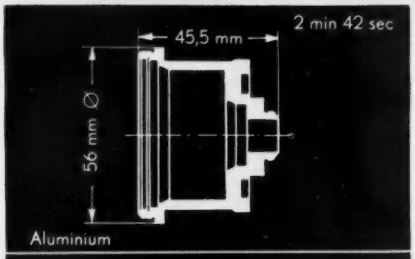
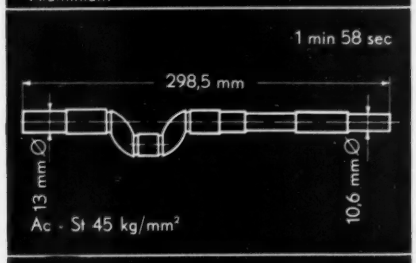
Please send me full details of "Barrymount" Levelling Machine Mounts.

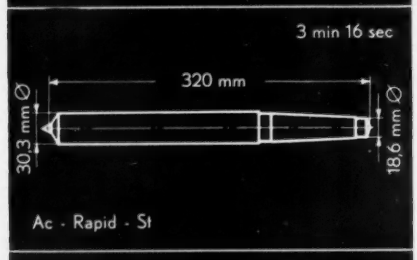
NAME .....

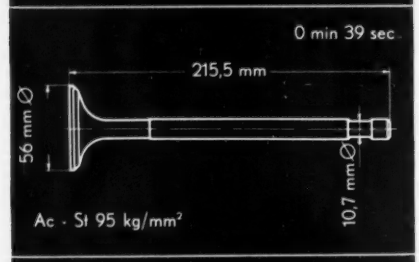
POSITION IN COMPANY .....

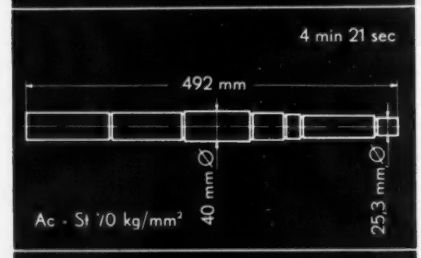
COMPANY'S NAME AND ADDRESS .....

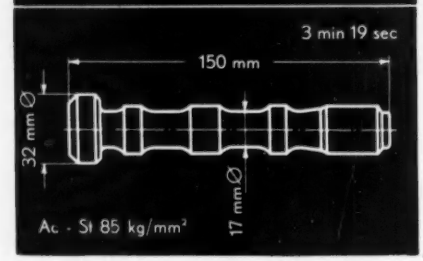












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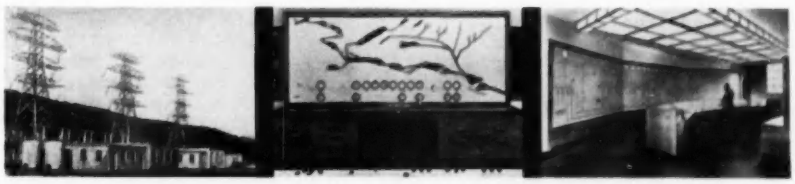

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Nr. Pitlochry
Perthshire

Standard Telephones and Cables Limited

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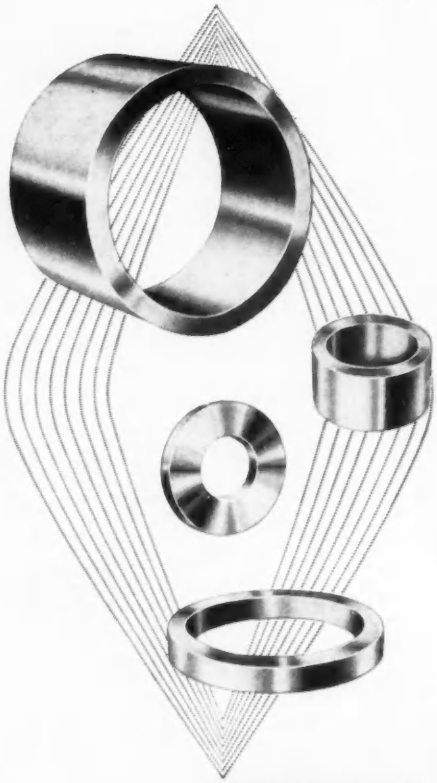
TELEPHONE DIVISION: OAKLEIGH ROAD, NEW SOUTHGATE, LONDON, N.11

centrifugal force

the governing factor



The steam engine governor is a classic example of the application of centrifugal force.

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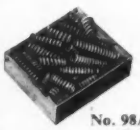

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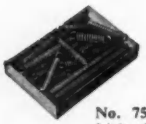

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The illustration shows the instrument in use checking the surface finish of a circular component after being ground on a Jones & Shipman universal grinding machine.

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N.B. Our illustration shows a 5ft. machine drilling handle attachment holes 1.37/64" diameter in driver gear housing for light overhead cranes.

Photographs by courtesy of the YALE & TOWN Manufacturing Co. Materials Handling Division, Wednesfield, Staffs. Manufacturers of YALE Materials Handling Equipment.

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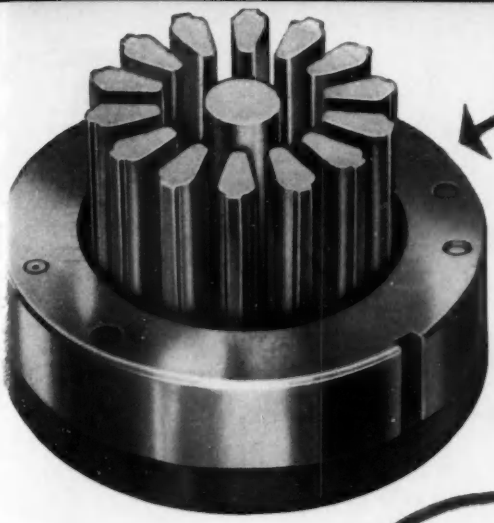
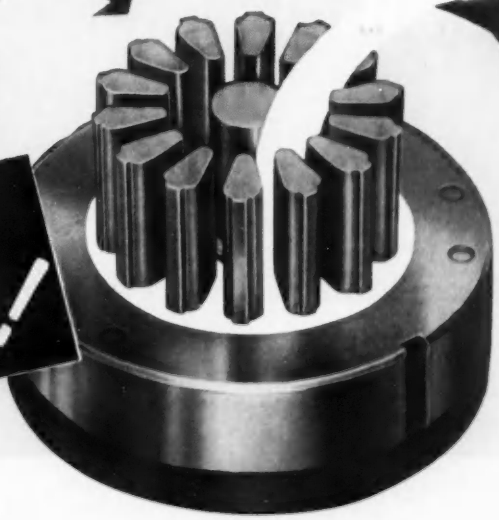


IN THEY GO -

- IN THEY STAY

without any machining!



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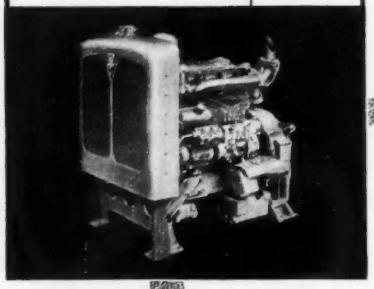
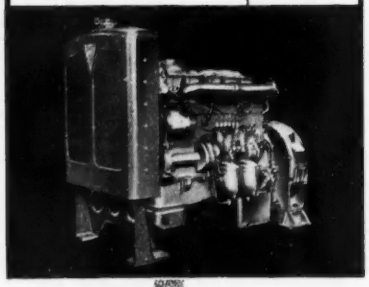
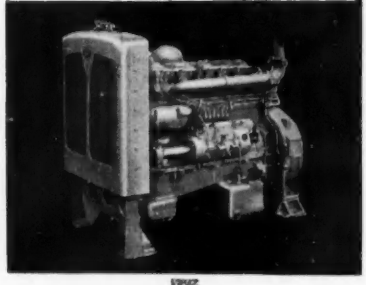
AV312G 4-cyl. diesel engine. **75**



AV470G 6-cyl. diesel engine. **125**



A221K 6-cyl. diesel engine. **150**



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. . . with the adjustable flow range — easily set for high or low rates of flow.

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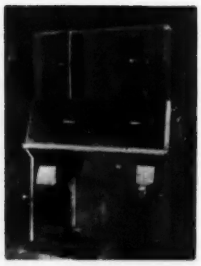

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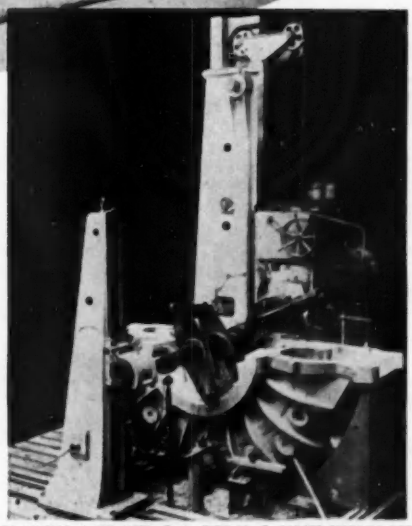

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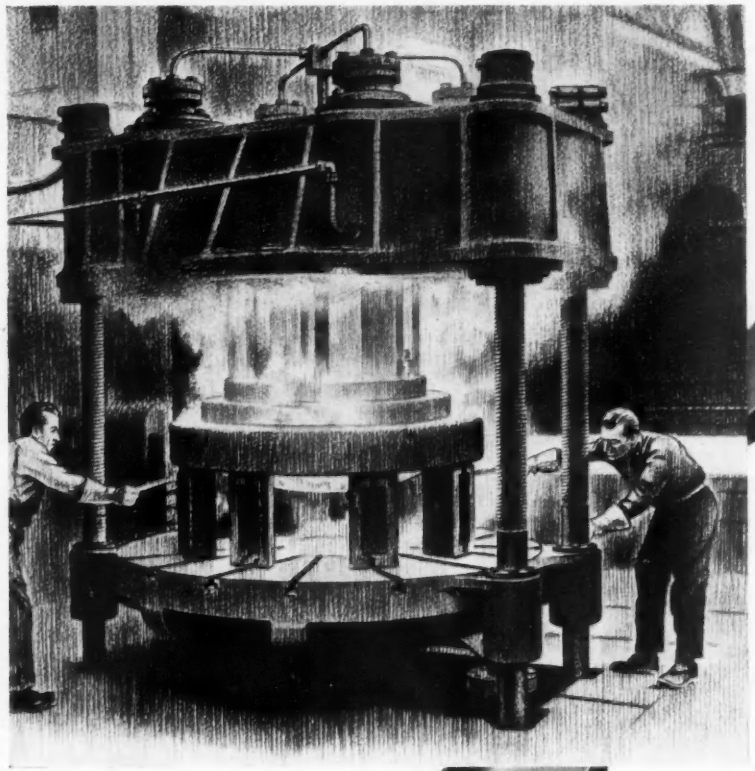

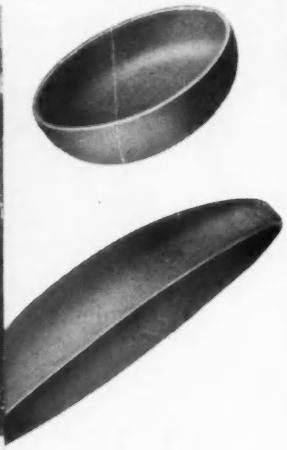

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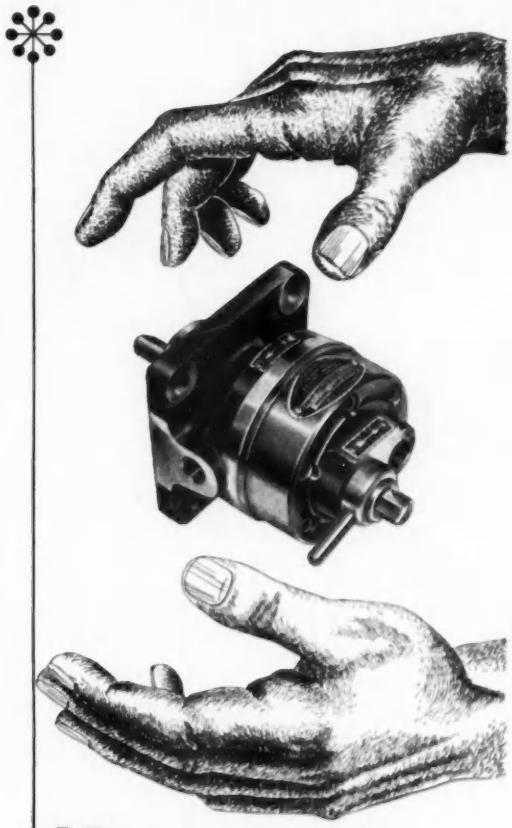

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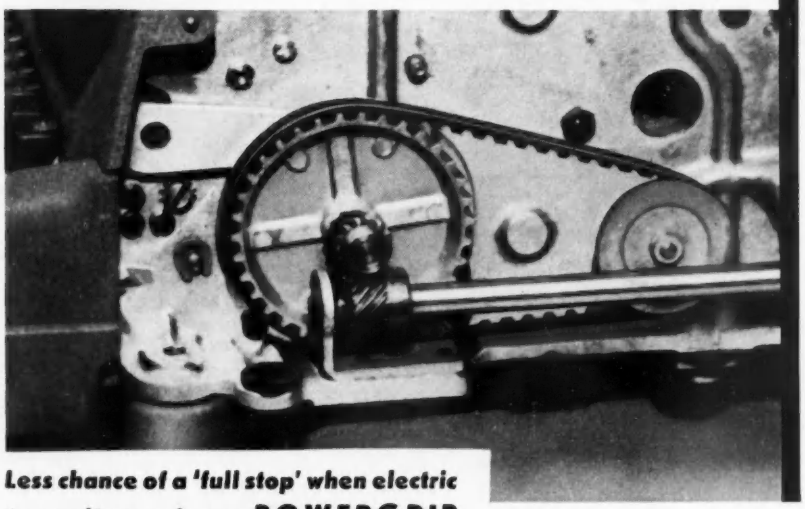

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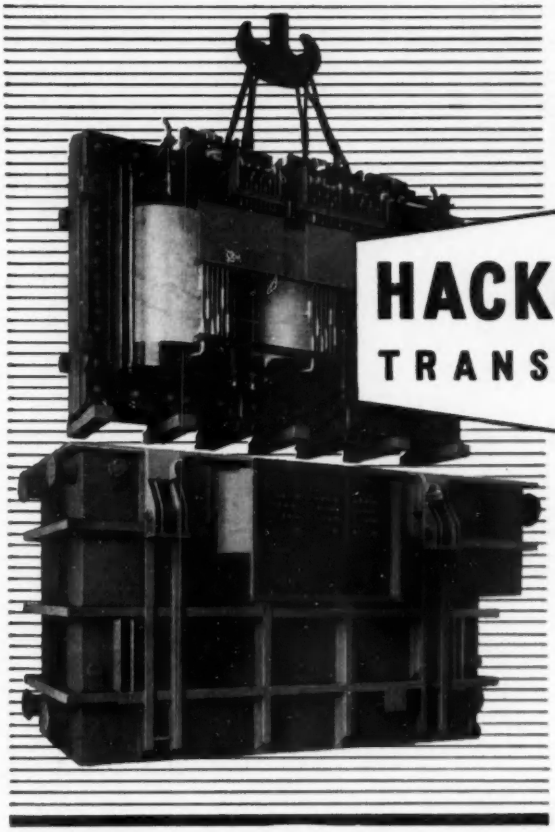

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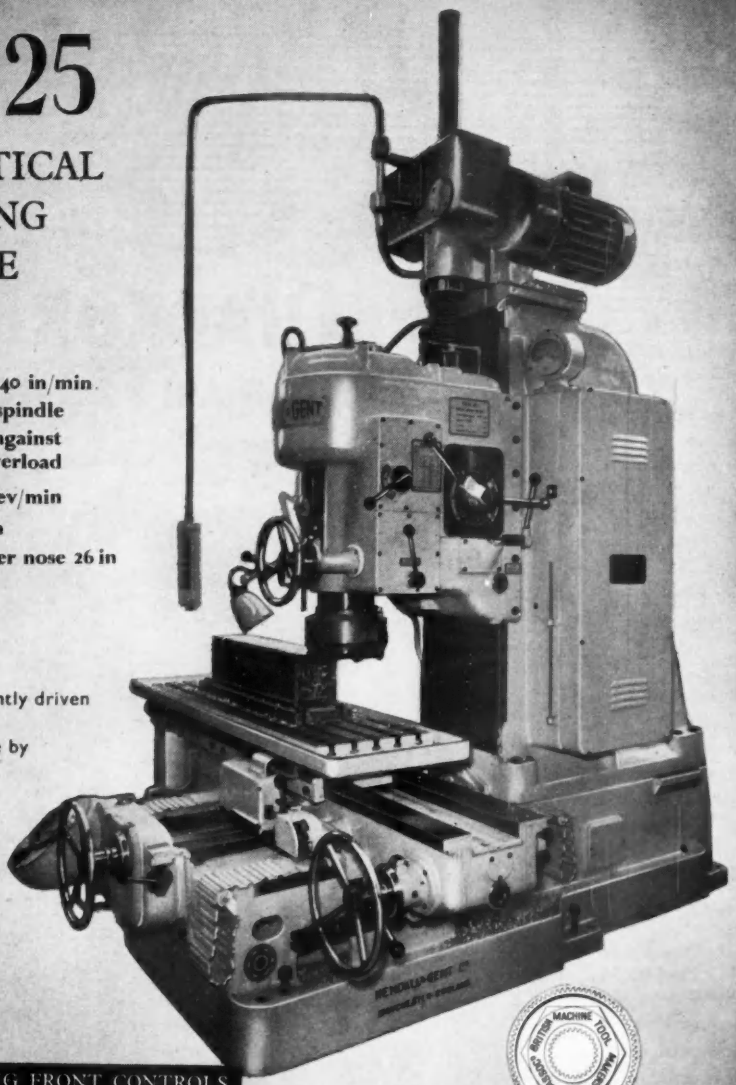

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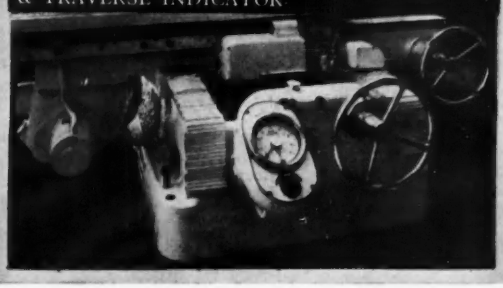

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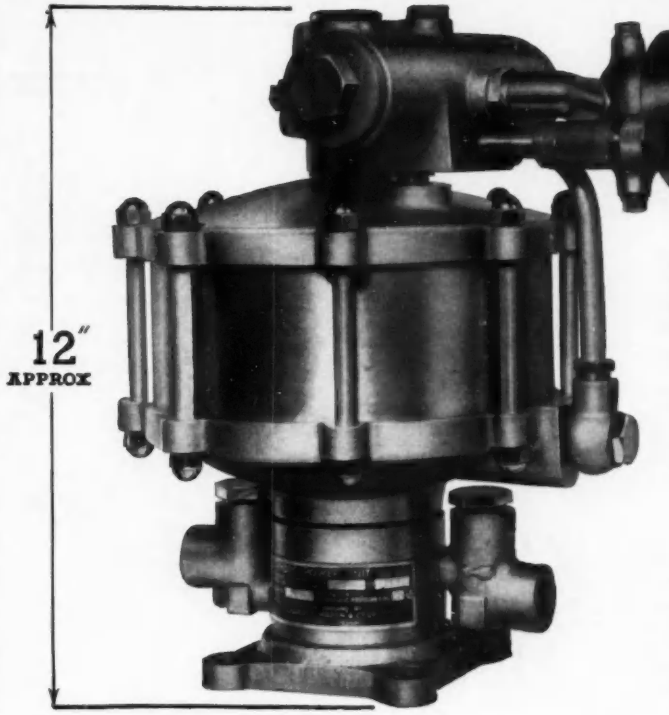

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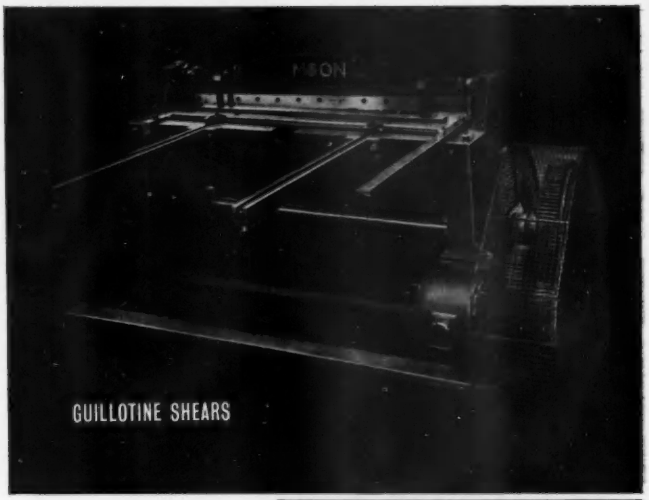

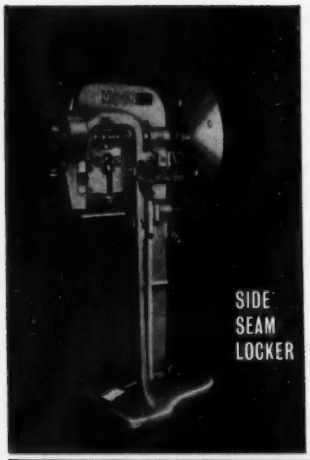

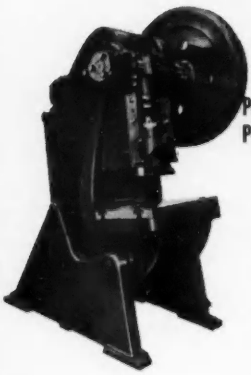

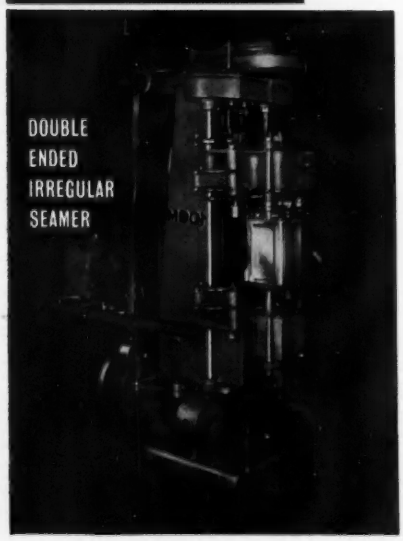

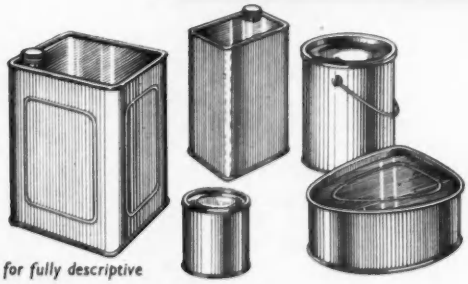

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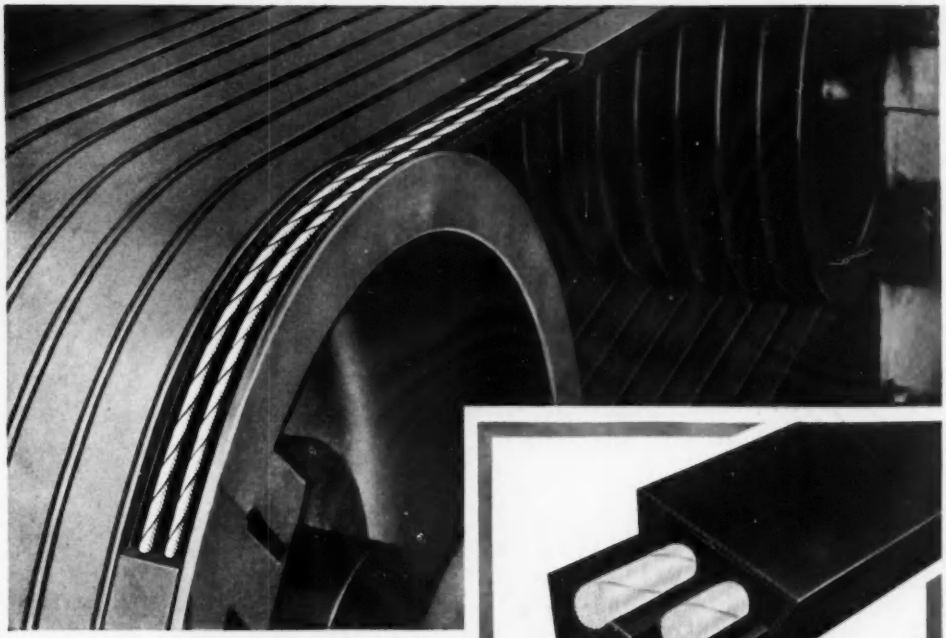

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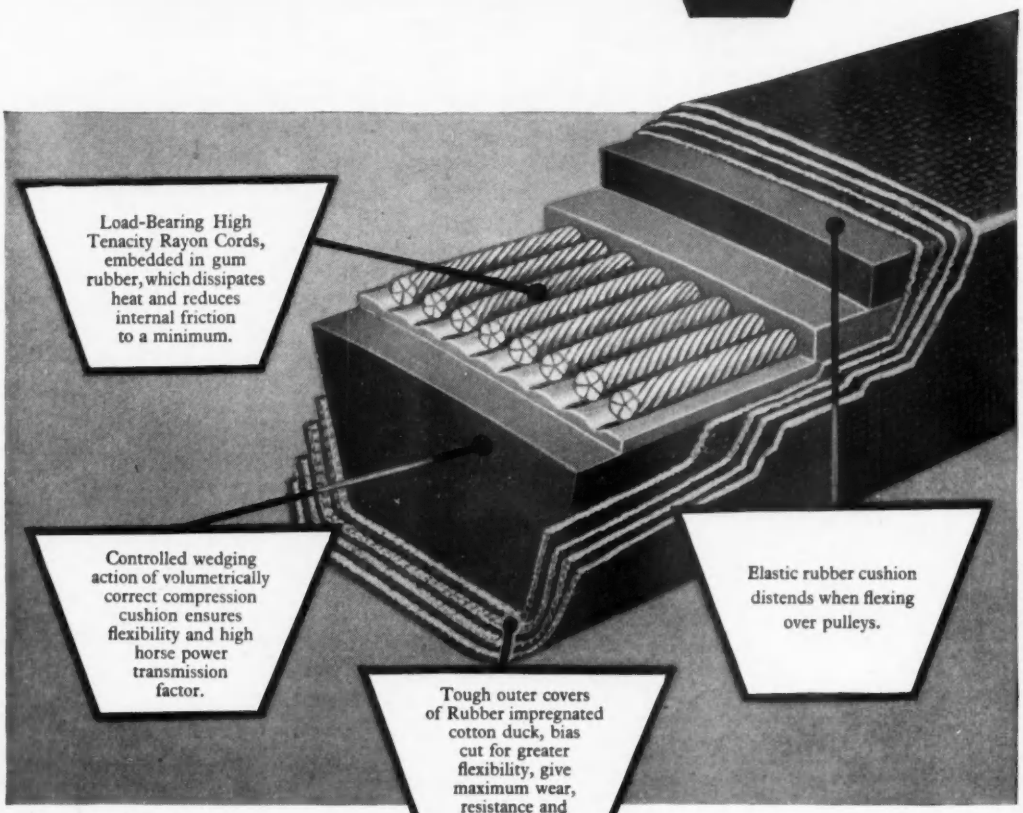
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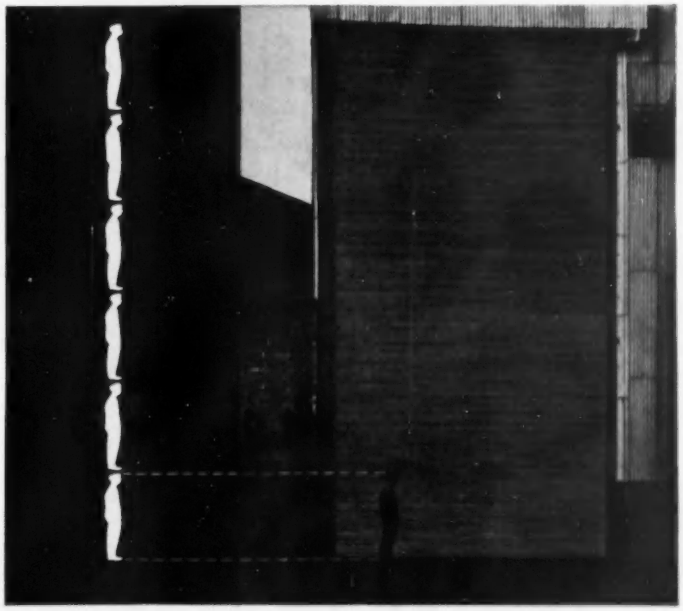

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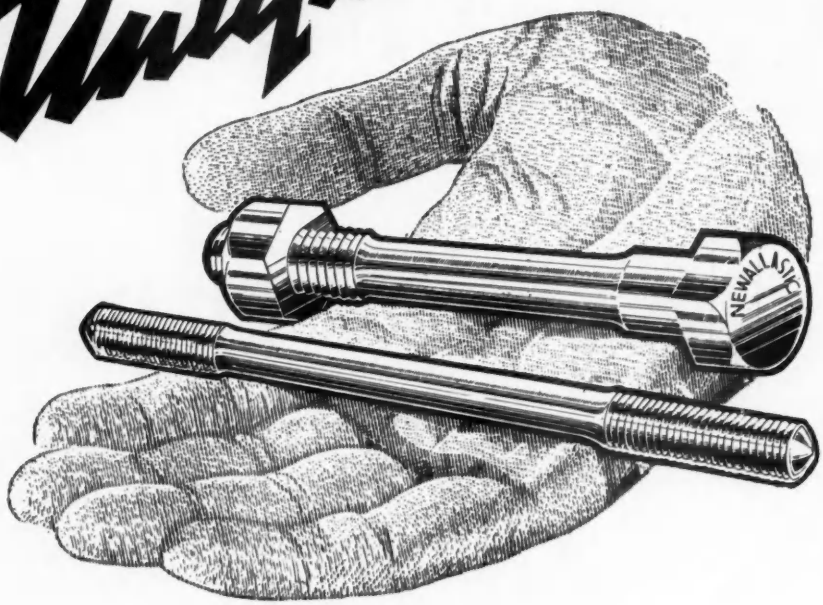

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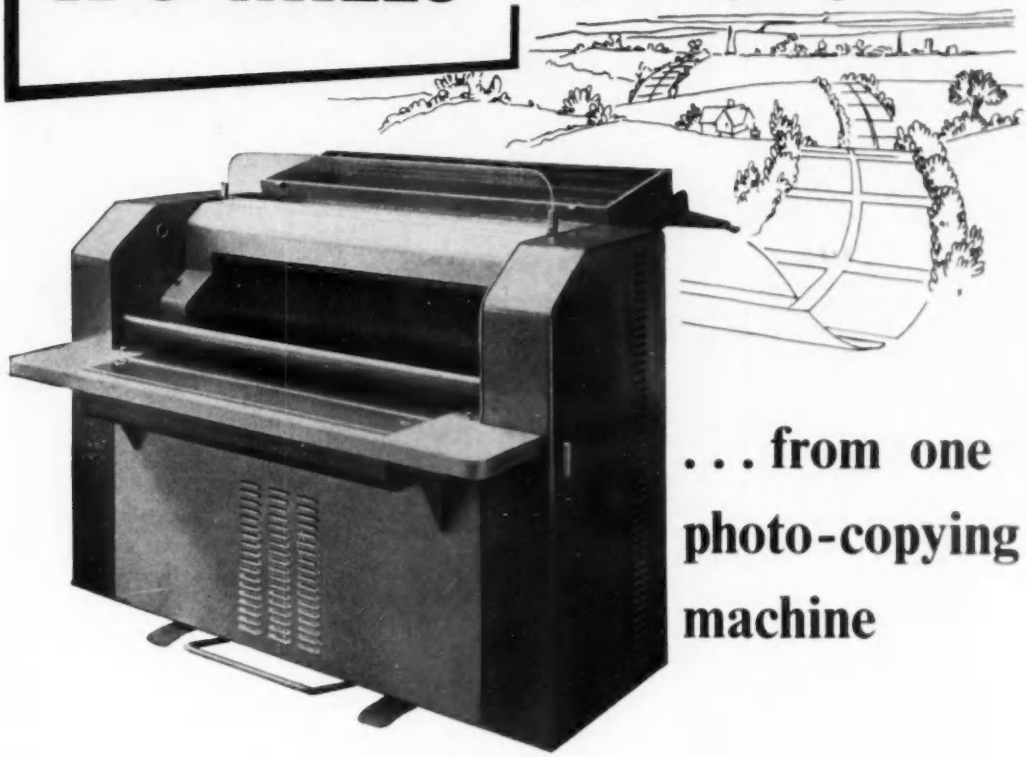

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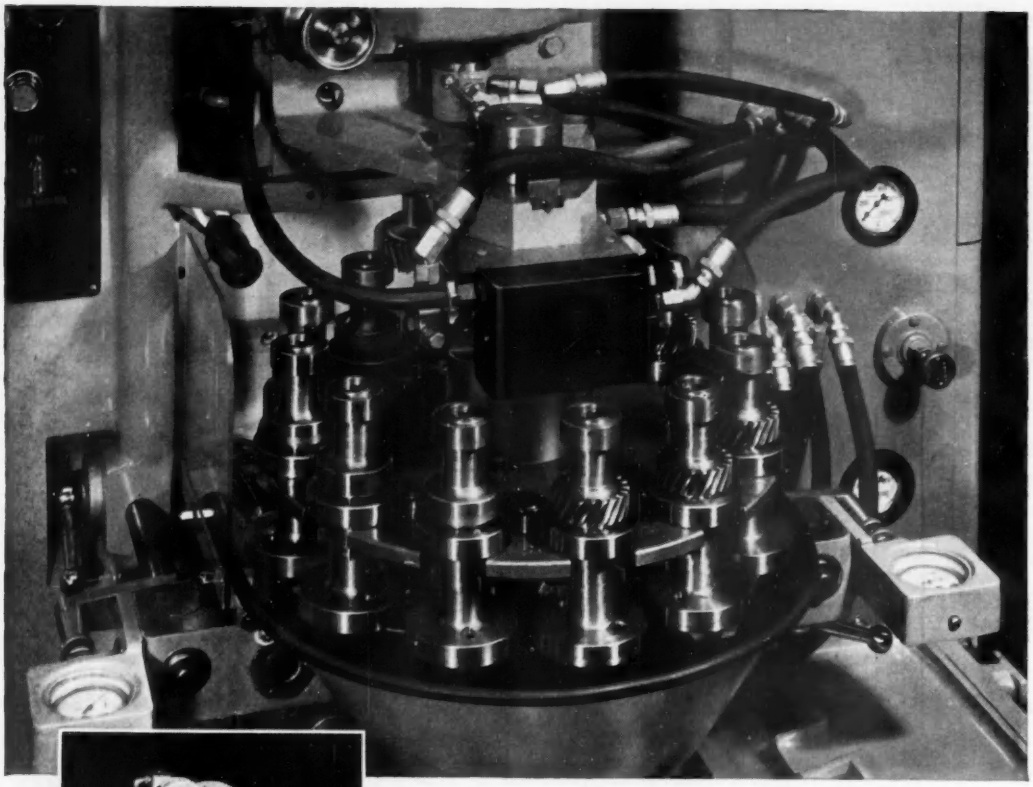

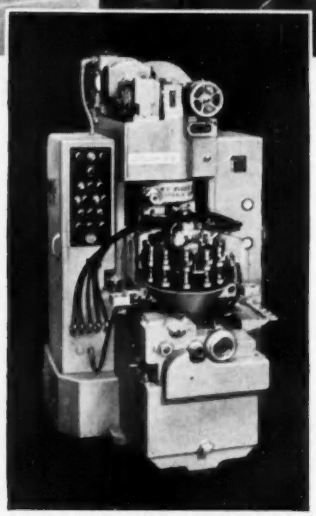

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CONTENTS

	Page
The Blue Pages	133
New Permanent-Magnet Couplings using Sintered Oxide Materials	137
Acoustic Absorption of Porous Materials Covered with a Protective Layer	139
High-Vacuum Electron-Beam Fusion Welding	141
Properties and Applications of "DU" Unlubricated P.T.F.E.-Type Bearings	143
Ultrasonic Testing of Insulating Materials used in Transformers	147
Cutting Tools with Helical Carbide Teeth	149
The Atomization of Liquids by Flat Impingement Nozzles	151
Heteropolar Synchronous Machine with Unwound Rotor	156
Fuel-Ash Attack on Aluminium-Coated Stainless Steel	157
British Industrial Developments	159
Additional Abstracts	163
New Materials, Processes, and Equipment	165
News of the Month	171
New Technical Books	176
Latest Industrial Literature	A89

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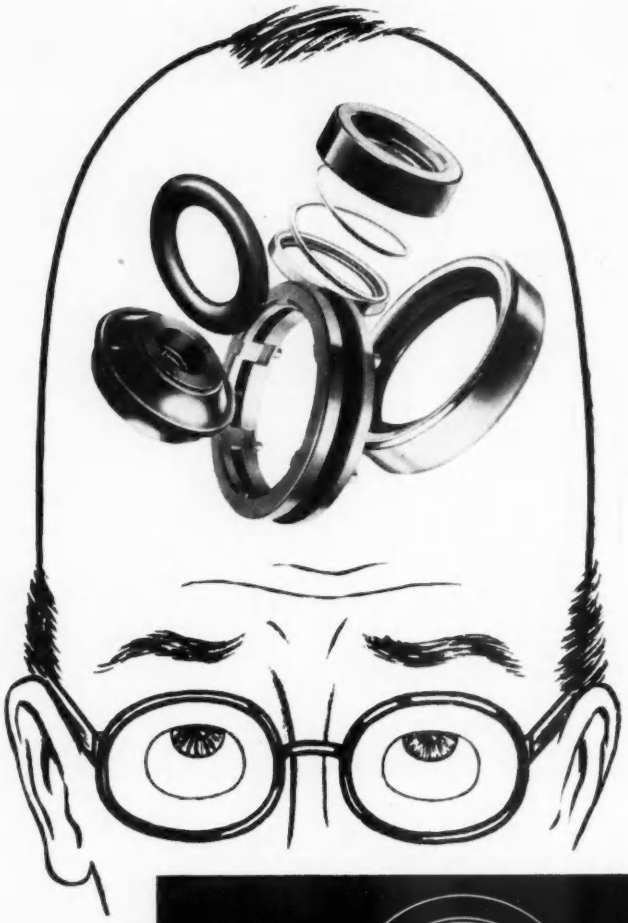

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• *RESIDUAL GRINDING STRESSES IN TITANIUM*

During the past few years, several investigations have been carried out with respect to the various phases of residual grinding stresses in steel, but little work has been done on the residual-stress distribution in titanium. A recent research report presents the results of an initial study made to determine the effects of surface-grinding conditions on residual stresses in a titanium alloy. Additional work is contemplated in which the correlation of residual stresses and fatigue life in titanium will be studied. The test specimens were milled and finished by grinding to 3 × 6 × 2 in., with the grain parallel to the 6-in. dimension, and vacuum-annealed at 1250°F for 36 hr. The thickness of the testpieces was measured with a micrometer before and after each grinding test to determine the amount of stock removed, and the grinding ratio, i.e., the volume of material removed per unit volume of wheel wear, was computed. In the course of testing, several grinding variables were studied, including wheel type, wheel speed, grinding fluid, and feed. Tests were made by changing one variable at a time, so that the effect of each could be evaluated separately. After grinding, each specimen was placed in an optical interferometer to obtain interference patterns caused by curvature of the polished face, resulting from the removal of each increment of ground surface. Material was removed with an appropriate etchant, and uniaxial residual stresses were calculated from changes in the longitudinal curvature of specimens as layers of ground surface were removed. The grinding tests revealed the fact that there are two definite possibilities for grinding titanium successfully, i.e., by the low-speed method, and by the near-normal-speed method. Residual stresses from either method are low.

• *TRANSPARENT PHOSPHORS FOR CATHODE-RAY TUBES*

A transparent phosphor has been developed which is claimed to improve greatly practically all aspects of cathode-ray tube displays. Thus, background illumination, from either ambient light or the electron spot itself, does not affect the display on a transparent screen, whereas on a cathode-ray tube with a conventional phosphor the desired display must be produced on top of the background light, thereby limiting contrast and resolution. Because of the thin, non-scattering nature of the transparent phosphor screen, there is a theoretical resolution of about 10,000 lines per inch, compared with a standard phosphor screen with optimum design and operating conditions, which permits resolution of the order of only 500 lines per inch. With transparent phosphors, displays can be made under conditions of extremely high ambient lighting, the normally diffuse reflecting surface of a standard phosphor having been eliminated, so that incident light is not reflected. Instead, the incident light is trapped inside the transparent phosphor tube, resulting in excellent contrast. Furthermore, conventional phosphors dissipate heat from the high-voltage electron beam in each individual crystal. Excessive heat dissipation causes burning of the phosphor, and the screen therefore blackens, eventually limiting the usefulness of the tube. On the other hand, with transparent phosphors there is intimate contact with the glass face-plate of the tube, permitting heat dissipation into the glass itself and giving more light output without screen degradation. It is claimed that from 50 to 500 times more beam current can be used safely without deterioration of these phosphors and, by applying separate layers of transparent phosphors to a tube face, blue and yellow colour changes can be produced. Changing the operating voltage of the cathode-ray beam controls the penetration of electrons into the phosphor layers, so that colour output is determined by the depth of penetration.

• *METHOD OF DE-OXIDIZING IRON AND STEEL SURFACES*

A recent patent proposes a novel method for the removal of oxide from iron and steel surfaces, leaving the underlying surface in a condition in which it is not readily re-oxidizable. Naturally, many operations in the manufacture of steel and of iron or steel articles, such as heating operations, result in the production of a relatively heavy layer of oxide, and even such corrosion-resistant materials as stainless steel will, under certain atmospheric conditions, become slightly oxidized. Because of these oxide films, it is difficult, if not impossible, to provide coatings of other metals by such methods as vapour, chemical, or electroplating. While acid solutions will often remove the oxide, in many cases they will also attack the underlying metal ; in any event,

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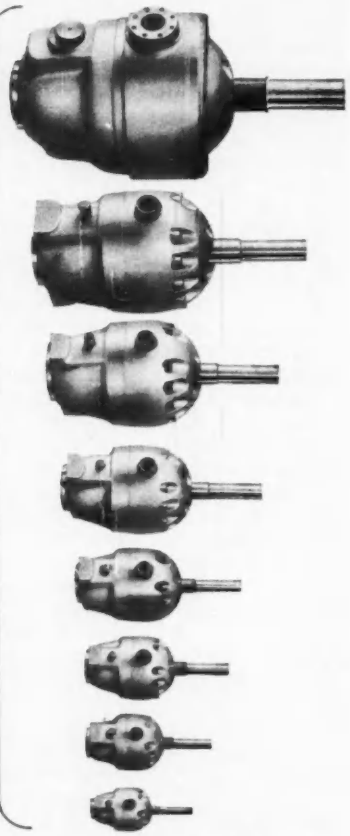

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on removal from the de-oxidizing bath, the metal rapidly re-oxidizes, this being particularly true in the case of hydrochloric acid. Because of the rapidity of re-oxidization, the parts must be almost immediately subjected to the plating operation. The new method includes the use of a de-oxidizing bath comprising a solution of hydrochloric acid and ammonium chloride in water, the concentration of the ammonium chloride being at least 10 grams per 100 millilitres of solution. The bath is maintained at an elevated temperature at the time the oxide is removed from the metal articles. At temperatures below 50°C the time required for removal of the oxide may be too long for practical application but, at temperatures of 50°C and above, the oxide will be removed very rapidly, the higher the temperature the faster being the removal of oxide. The bath temperature may be near the boiling point of the solution, i.e., about 80°C.

● ***METHOD OF DAMPING VIBRATIONS IN GAS-TURBINE ROTOR BLADES***

In modern aviation gas turbines, it has been found that, under certain conditions, the rotor blades undergo large vibratory stresses which may cause rupture. These stresses may be caused by resonant effects, a stall-flutter condition, or a rotating-stall condition. In order to alleviate such high stresses, current approaches to the problem are to design the blades to a given natural frequency or, alternatively, to increase the damping in the blade. A recent investigation into the latter method for reducing blade stresses has taken into consideration a number of remedial measures. One such measure involves insertion of particles of different sizes and kinds of materials into a hollow blade. This method yields damping for stationary, non-rotating blades but, when the blade is rotated, the particles pile together, giving only slight relative particle motion and therefore producing little damping. Another method is the use of two flat cantilevered plates under normal force, one rubbing against the other when vibrating. Damping is obtained with this device, but the damping is dependent on the normal force, which is difficult to control. A third measure comprises root damping of the vibrating blade. Here again, the normal force is the critical factor, as too great a normal force prevents relative blade-root motion and too small a force reduces the energy-absorption capacity. A fourth method, using tuned dampers in the tip of the blades, has also been tried. These dampers are relatively effective, but only in a narrow frequency band. The report on the investigation referred to points out that analysis of the damping provided by the method using flat cantilevered plates, one rubbing against the other, could give damping if the inertia force of the mass of the plates could be used as the normal force. This has suggested that a device was required which had mass, but little shear-carrying capacity, and which would allow the inertia force of its mass to be used as a normal force. Wire strands have been found to fit this requirement, and tests have shown that the wires do, in fact, give the required high damping.

● ***CASTING FERROUS METALS IN ANODIZED ALUMINIUM MOULDS***

Permanent mould casting fills an important need in the metal-forming industry and, if it could be expanded so that a wide range of ferrous metals could be cast, its usefulness would be greatly enhanced. The reasons why permanent moulds are not suitable for the casting of ferrous metals are mainly aspects of heat transfer and heat dissipation. The conventional type of permanent mould is almost always made up of two or more massive iron castings with a relatively low rate of heat transfer, owing to the low thermal conductivity of cast iron. As a result, when a ferrous metal is poured, the metal surfaces overheat, with consequent destruction of the mould. Other limiting factors are the cost of the moulds and the low rate of production. It is claimed, however, that these drawbacks can be solved, or at least minimized, by using permanent moulds of anodized cast aluminium, which has about three times the thermal conductivity of cast iron. As a result, for the same temperature difference and the same area, three times as much heat can be conducted away from the casting-mould interface per inch of mould thickness per second. The inference is that a much higher metal temperature can be tolerated, provided that the molten metal does not solder to the mould surface. Experimental investigations have shown that this will be prevented if the aluminium surfaces are anodized, an oxide coating forming on, and adhering tightly to, the mould surfaces and providing a good barrier between the liquid metal and the mould surface. It is claimed that, in this way, it is possible to design a cast-aluminium mould into which even metals with high melting points can be cast.

● ***IMPROVED EDDY-CURRENT METHOD OF CRACK-DETECTION FOR FERROMAGNETIC MATERIALS***

Whilst the eddy-current method of detecting cracks and flaws generally gives correct results with non-magnetic materials, difficulties arise when testing ferromagnetic materials, owing to alterations in permeability caused by small local deformations produced by cold working the article to be tested. These alterations give rise to fault indications of the same magnitude as those for cracks or irregularities in the composition of the material. In order to render the eddy-

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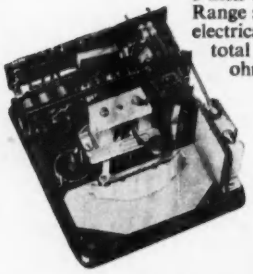

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current method applicable to the testing of ferromagnetic materials, proposals have been made to premagnetize the article to be tested to its true magnetic saturation, with a view to ensuring that it behaves in the same way as a non-magnetic material. Now, however, a recent patent claims that the same effect can more simply be achieved by applying the eddy-current testing method to the article while it is heated to at least that temperature at which the material is no longer magnetizable. In the case of steel, this temperature is 768°C (Curie point). It is claimed that, compared with the premagnetization process, the new method requires considerably less technical expenditure, and is considered to be especially useful where the soundness of a seam-welded joint, e.g., a seam-welded pipe, is to be tested. These pipes are frequently heated to about 800°C after welding, for the purpose of normalizing or annealing ; it is therefore possible to make use of this heating operation by carrying out testing of the seam with the eddy-current method during the normalizing or annealing process.

● *RELAYS WITH MULTIPLE-BALL CONTACTS*

A new type of relay has been developed in which plated balls are used as contacts, movement of the balls into contact position being accomplished by electromagnetic action produced by solenoids or other suitable magnet coils. As the ball armature represents little mass, the number of ampere turns required to produce fast, positive action is small. It is claimed that, by selection of contact materials of appropriate relative hardness, the balls can be made to absorb most of the contact wear and, since a ball presents an infinite number of contact surfaces, the effects of such wear are greatly retarded. The prime concern in selecting the plating material for the balls is to obtain minimum contact resistance ; of the materials investigated, silver-cadmium oxide, rhodium, palladium, and platinum are reported to show the most promise, and silver-cadmium oxide plating has been adopted as the general-purpose standard. Ball size has been standardized as 0·2532 in. diameter for general-purpose relays. Extensive studies are being made on several types of multiple-ball contact devices, which employ a large number of small balls in a contact chamber consisting of a vertical hollow cylinder of a dielectric material which is closed at both ends by plugs. These plugs constitute stationary contacts and are connected to the output terminals of the relay. The upper contact plug is surrounded by a magnet coil and, by passing a current through the coil, a magnetic field is created which causes the balls to rearrange themselves to form a continuous mass extending from the upper contact to the bottom contact. By using a group of magnetically permeable rods in place of a plug it is possible to control the alignment of the balls into strings, in accordance with the lines of magnetic flux.

● *PROTECTION OF OXIDE-COATED CATHODES BY ION TRAPS*

Ions, created by collision between electrons and residual gas molecules, are destructive to oxide-coated cathodes, and this problem becomes more acute with higher voltages. In addition, mica supports and other insulators may develop leakage paths as a result of positive ion bombardment. To minimize this problem, special precautions must be taken in the fabrication of high-voltage tubes with oxide-coated cathodes. For instance, the bake-out, pumping, and gettering procedures must be made more thorough ; alternatively, the destruction of the cathode at high voltages may be largely avoided by replacing the oxide-coated cathode with a tungsten or thoriated-tungsten emitter. However, such cathode materials imply the use of much higher filament temperatures and of more complex procedures of manufacture. It is now reported, however, that, by providing a built-in ion trap, the service life of thermionic valves with oxide-coated cathodes can be considerably extended. Thus, for instance, it is reported that high-voltage pentodes equipped with an ion-trap have a life in excess of 2000 hr. By means of the ion trap, positive ions are prevented from reaching the cathode. An indirectly heated oxide-coated cathode is surrounded by control and screen grids in the conventional manner, and a cylindrical collector, open at one end, surrounds the screen grid and is connected to it. Thus, in the absence of plate voltage, an essentially field-free region is created in the interspace. Positive ions created in the anode region are deflected downwards towards the bottom of the collector, rather than to the screen grid or to the electrodes inside the screen, because the positive ions travel with a velocity whose downward component is much larger than any horizontal component.

● *HEAT-RESISTANT METHYLSTYRENE THERMOPLASTICS*

A new methylstyrene thermoplastic has been announced which is claimed to retain good insulating and electrical properties under severe service conditions such as high temperature and humidity, and also to have good wear resistance. For instance, sleeve bearings machined to close tolerances from the extruded material have operated without lubrication on a steel shaft rotating at 1750 rpm at a *PV*-factor of approximately 16,200, with significantly less wear than that of nylon bearings of the same size and tested under the same conditions. Other properties

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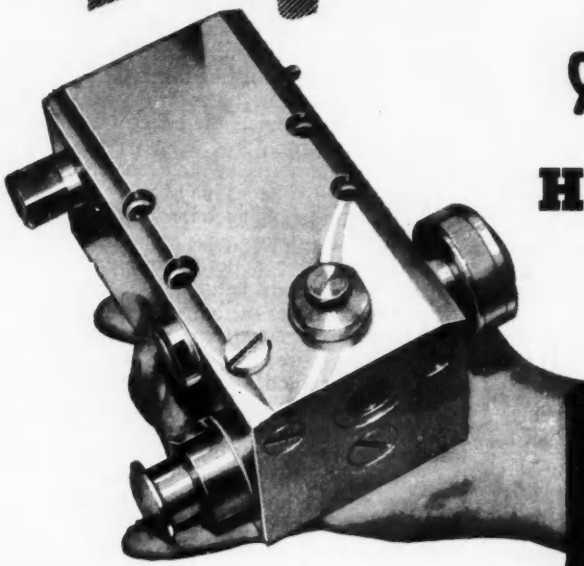

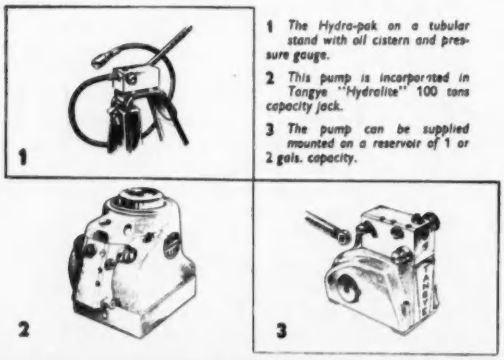

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listed for the new material are good heat stability and resistance to deformation at relatively high loadings and high temperatures. The material can be readily moulded and extruded in conventional moulding equipment, moulding temperatures generally ranging from 450 to 525°F. Moulded and extruded parts can be machined to close tolerances by using machining speeds similar to those used for good-quality brass and aluminium. It is worth recalling that other methylstyrene compounds introduced about two years ago have proved their value in practice, and in certain cases have replaced polystyrene, acrylic, acetate, and polythene materials. Polymethylstyrene, for instance, has a heat-distortion point of 203°F, comparing favourably with 185°F for general-purpose polystyrene and with 190 to 199°F for heat-resistant polystyrenes. The shrinkage of polymethylstyrene after 30 min in boiling water is 0·2%, as against 1·5% for heat-resistant polystyrene. Acrylonitrile-methylstyrene has a heat-distortion temperature of 207°F, and its shrinkage after immersion in boiling water for 30 min, followed by exposure to dry heat at 225°F for 2 hr, is 8%, whereas ordinary heat-resistant polystyrene is completely warped.

● *CERAMICS FROM GLASS*

Glass-ceramics, known under the proprietary name of " Pyroceram ", have now become commercially available, and several possible applications are in the development stage. A particularly interesting application at present being investigated is the manufacture of ball bearings made entirely of the new material. It is reported that tests have shown that these bearings will operate at up to 1000°F without lubrication and at loads approximating one-half the capacity of stainless-steel bearings at this temperature. When ceramic bearings fail, it is apparently by gradual erosion rather than by chewing action. This is an added advantage where sudden jamming of equipment cannot be tolerated. It is expected that, if the experimental work in course of progress is successful, bearings of this type may find application in turbines and pumps operating in the 500°F temperature range. Glass-ceramic pistons for diesel and other types of internal combustion engines are considered as another interesting possibility. A continuing problem in engine design has been the difference in the thermal-expansion coefficients between piston and cylinder-wall materials, while corrosion by combustion products is another problem. The use of glass-ceramics should make possible close control of expansion coefficients, and, bearing in mind its good mechanical strength and hardness, its use may well pave the way to novel engine types. Glass-ceramics are essentially materials which has been converted into ceramics from their original glassy state by the use of nucleating agents and the application of carefully controlled heat treatment. By adding such agents to a glass batch, extremely large numbers of submicroscopic crystallites are formed on cooling. When the glass is reheated to the proper crystallizing temperature, each crystal nucleus acts as a centre for further crystal growth. Depending on the original glass composition and heat treatment, various degrees of crystallization are possible, thus creating a completely new material.

● *OXIDATION CATALYSTS FOR REDUCTION OF HYDROCARBONS IN AUTOMOBILE EXHAUST GASES*

In a recent investigation of oxidation catalysts suitable for the reduction of hydrocarbons in automobile exhaust gases, a vanadium oxide catalyst was found to be reasonably tolerant of lead solids in the exhaust, showing an effectiveness of more than 80% in the first hours of testing, and a hydrocarbon conversion of more than 50% over a 175-hr test. To attain and maintain this effectiveness, an operating temperature range of 550 to 900°F is required, imposing a design limitation in that any useful device embodying this catalyst must be located near the engine to permit rapid warm-up. A by-pass may be necessary to prevent overheating when operating conditions produce unusually high hydrocarbon concentrations in the exhaust gas, but the vanadium oxide catalyst tends to reduce the problem of heat dissipation because it oxidizes a major portion of the hydrocarbons to carbon monoxide and does not oxidize the carbon monoxide already present. Owing to this characteristic, it is believed that a container fabricated from mild steel would have a satisfactory life with this catalyst. Tests were conducted on a single-cylinder engine using leaded and unleaded fuel, and parallel tests were conducted with platinum and nickel as catalysts. Platinum was found to be a remarkably effective catalytic material with unleaded fuel, and 100% hydrocarbon conversion was obtained for the duration of the test. On the other hand, nickel never attained an efficiency of more than 50% and gradually declined in activity. In addition to vanadium oxide, two other oxides were evaluated, i.e., copper oxide and iron oxide. Iron oxide was found to have a low initial efficiency and to decline rapidly in effectiveness, while copper oxide gave a high conversion, but only for a short time.

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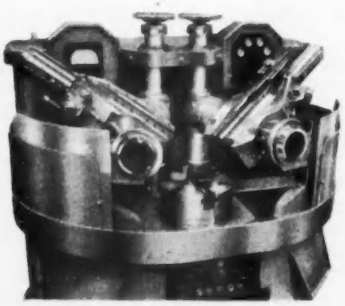

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REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIX No. 4 APRIL, 1958

New Permanent-Magnet Couplings using Sintered Oxide Materials

By E. SCHWABE. (From *Feinwerktechnik, Germany*, Vol. 62, No. 1, January 1958, pp. 1–8, 8 illustrations.)

IN engineering, permanent-magnet couplings have been known and used for some time in special applications. Thus, for instance, in some types of flow meters rolled-steel or Alnico magnets have been employed for a number of years to provide frictionless transmission of rotary motion from a wet chamber to a dry chamber. However, up to the present, the industrial use of magnetic couplings on a broader basis, e.g., for small circulating or delivery pumps, compressors, and other units which are often required to operate for many years without maintenance, has not been considered practicable, because of the cost, size, and design considerations associated with the magnetic materials hitherto available. The new magnets of sintered oxides of barium and iron ($BaO.6Fe_2O_3$) described in this article offer considerably greater possibilities.

DESIGN FEATURES OF THE NEW COUPLINGS

In this investigation, two sintered materials of the $BaO.6Fe_2O_3$ type were used, i.e., the isotropic material "Oxit 100" and the anisotropic material "Oxit 300 KK", specially developed for couplings and made by Deutsche Edelstahlwerke, of Krefeld, Germany.

Fig. 1 shows intensity of magnetization J as a function of field strength H for these two materials. It should be noted that these J/H curves should not be confused with the B/H curves of magnetic induction as a function of field strength normally used.

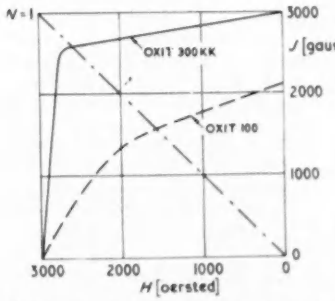

Fig. 1. J/H demagnetization curves of two types of $BaO.6Fe_2O_3$ materials.

Both materials have reversible operating properties down to —20°C between the remanence point (intersection of the curves with the J-axis in Fig. 1) and the ${}_BH_c$-point (intersection of the curves with diagonal $N = 1$, where N is the demagnetizing factor, i.e., the ratio of the opposing field inside the magnet to the magnetizing flux density which causes it to occur). ${}_BH_c$ can be defined as the coercive field necessary to reduce the magnetic induction B to zero. Fig. 1 shows that, with a decrease in the opposing field strength H, J increases only slightly for these materials.

For rotary couplings, two basic types of which are considered in Figs. 2 and 3, the transmitted torques are of primary interest. Fig. 2 shows a concentric-sleeve type of coupling, in which the outer ring is rigidly attached to the driving member and the inner ring to the driven member of the coupling. In the smaller sizes, the innermost ring, constructed of soft iron, for the return circuit is omitted, on account of manufacturing difficulties, and instead the inner magnet is made of correspondingly greater thickness and is subjected to lateral (instead of radial) magnetization.

The maximum transmissible torque T_{max} can be estimated from

$$T_{max} \cong 2 \times 10^{-7}\, C\, {}_BH_c^2\, R^2\, b\, [1-(4l_L/p)]^2 \quad .. \quad (1)$$

where R is the effective torque arm (Fig. 2), b is the length of the magnet, l_L is the width of the air gap, p is the distance between equal poles, and C is an empirical factor between 0·5 and 1·5, depending on design and manufacturing considerations, but in this case has been taken as unity. For a suitable arrangement, $p/4$ can be taken as equal to $l_L + 2l_M$, where l_M is the width of the magnet, so that $p = 4\ (l_L + 2l_M)$; b is considerably greater than $p/4$.

As an example, in which the dimensions chosen are such that it is possible to construct each coupling magnet in one piece, assume that $R = 4$ cm, $b = 5$ cm, $l_L = 0{\cdot}4$ cm, $l_M = 0{\cdot}85$ cm, so that $p = 8{\cdot}4$ cm (six poles), and ${}_BH_c = 1600$ oersteds (corresponding to Oxit 100, as shown in Fig. 1). Then, T_{max} will be 26·8 cm kg, so that this coupling would be just capable of transmitting the nominal torque of a 1-hp motor at 2700 rpm.

Another arrangement of the coupling magnets is shown in Fig. 3, this being a face-type coupling of particularly simple construction. The magnets have the form of rings or plates, and the poles in this case are magnetized segments. The maximum torque T_{max} can be estimated from

$$T_{max} = 6{\cdot}7 \times 10^{-8}\, C\, {}_BH_c^2\, (R_2^3 - R_1^3)[1 - (4l_L/p)]^2 \quad (2)$$

where R_1 and R_2 are respectively the minimum and maximum torque arms (Fig. 3). This type of coupling gives particularly high performance, since the magnet rings can be made without difficulty from one piece of Oxit 300 KK for diameters up to 14 cm. For instance, with $R_1 = 3{\cdot}5$ cm, $R_2 = 7$ cm, $l_L = 0{\cdot}3$ cm, $l_M = 1$ cm, $p = 9$ cm (10 poles), and ${}_BH_c = 2600$ oersteds (for Oxit 300 KK), the maximum torque T_{max} is 100 cm kg. This coupling, therefore, would be capable of transmitting 4 hp at 2700 rpm.

Couplings of the type shown in Fig. 3 have, however,

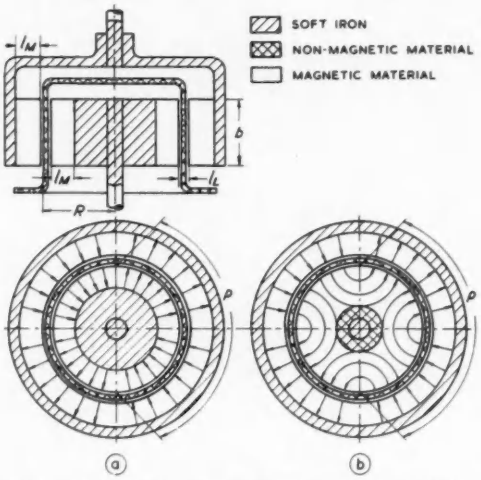

Fig. 2. **Basic design arrangement of four-pole concentric-sleeve couplings, with (a) the inner portion radially magnetized, and (b) the inner portion laterally magnetized.**

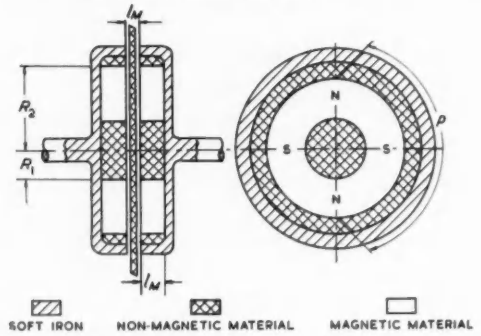

Fig. 3. **Basic design features of a four-pole face-type coupling.**

considerable axial forces in the most favourable energy position (with north and south poles facing each other), and these forces must be taken up by suitable thrust bearings. As an approximation, the axial pull F_{ax} [kg] can be taken as

$$F_{ax} = 4{\cdot}1 \times 10^{-8}\ {}_BH_c{}^2A \qquad .. \qquad .. \qquad .. \qquad (3)$$

where A is the area of the magnetic surfaces [cm^2]. Thus, in the example already considered, the value of F_{ax} is about 32 kg.

Temperature Behaviour

The temperature behaviour of these magnet materials has been extensively investigated. Reversible changes in their magnetic properties occur during heating, and these changes are primarily attributable to the fact that their saturation magnetization decreases by about 0·2% per °C over a temperature range from − 40 to + 150°C. For Oxit 100 and Oxit 300 KK, the remanences I_r and the coercive forces ${}_BH_c$ also have the same temperature variation. In design calculations, temperature variations can be taken into account by using a suitable value C_T (instead of C) for the torque coefficient, obtainable from Fig. 4.

The changes due to temperature are reversible; therefore, during heating, the C_T-value decreases, whereas it rises again to its initial value during subsequent cooling. Normally, the couplings considered will be used at temperatures not exceeding 150°C, but in some applications higher temperatures are stipulated. It may be noted that heating has no influence on coupling properties up to temperatures of 300°C.

Irreversible effects occur at excessively low temperatures, but these two Oxit materials have been developed in such a manner that their ${}_JH_c$-values do not affect their ${}_BH_c$-values (which determine the transmissible forces and torques), down to − 20°C, or even less with suitable design.

Applications

Couplings of the types described can be employed in a wide variety of engineering applications. They can be used (a) for the transmission of rotary motion through partitions, etc., (b) as misalignment couplings, and (c) as overload couplings, with adjustable slipping torque, where required.

The transmission of rotary motion through walls and partitions is a problem encountered in a very large number of applications. At present, it is mainly solved by means of stuffing-boxes, sealing-rings, etc. and occasionally by using squirrel-cage motors with an air gap sufficiently large to accommodate a tube in which the rotor and its bearings are situated. Another possibility is to have a totally enclosed motor with only its stationary power leads passing through seals or glands.

Stuffing-boxes and sealing-rings give rise to friction and wear, which are considerable disadvantages in small circulating pumps, compressors, and cooling units required to operate without maintenance for very long periods. With stuffing-boxes or sealing-rings for transmission elements, the sizes of gas and liquid flowmeters have to be increased considerably, to ensure that the friction of the output shaft has no effect on measuring accuracy. For rotating transmissions in high-pressure or vacuum applications, it is frequently necessary to have very complicated and delicate sealing arrangements.

Electric motors with a sealed rotor system have a lower efficiency than conventional designs, and are also larger and more expensive. The installation of the entire drive motor in the enclosed space is often not possible, because protection of windings against gases and liquids is frequently an expensive matter. Wherever torques are below 100 cm kg, and maintenance-free operation is required, couplings utilizing $BaO.6Fe_2O_3$ materials provide a most suitable solution. The couplings are extremely compact ; moreover, the magnetic material is immune to nearly all the usual chemical media, except hydrochloric acid. These couplings are much less expensive than Alnico couplings, owing to their very much smaller volume and cost.

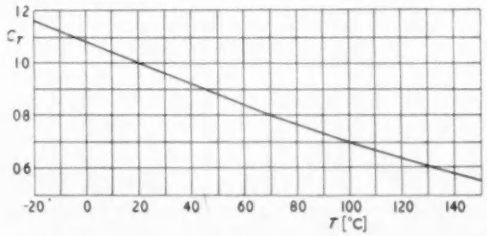

Fig. 4. **Temperature factor C_T as a function of temperature T.**

For general applications, the concentric-sleeve type of coupling is suitable. The sleeve-shaped magnets have ground surfaces and the outer magnet is provided with a dished and shrunk-on cover connected to the drive shaft. This cover also provides the magnetic return path and helps to resist centrifugal forces. In this connection, it may be noted that the mechanical behaviour of $BaO.6Fe_2O_3$ magnets is similar to that of ceramic masses with a high compressive strength but little tensile strength. The shrunk-on cover, therefore, is a most useful feature. The inner magnet can be magnetized laterally, so as to make the internal return circuit unnecessary. The shaft connected to the inner member is suitably provided with cast-on or sprayed-on layers of synthetic material. For greater economy, where torques do not exceed 10 cm kg, the coupling surfaces are not ground and the air gap is made correspondingly larger. The slight decrease in torque is made up by increasing the pole pitch and hence the ring thickness l_M. For torques greater than 10 cm kg it is preferable to employ the face-type of coupling arrangement. In this case, the magnet has an iron cover-

(*Concluded on page 155*)

ITALY

Acoustic Absorption of Porous Materials Covered with a Protective Layer

By E. Brosio. (From *Alta Frequenza*, Vol. 26, No. 6, December 1957, pp. 632–638, 12 illustrations.)

In the acoustic treatment of enclosures, extensive use is made of absorbent materials with a glass-fibre or mineral-wool base, which can be obtained in the form of semi-rigid panels, sometimes impregnated with resinous (bakelized) substances. These materials have good absorption characteristics which improve with frequency. Moreover, they are fairly easy to install and, because of their light weight, can be cemented to walls or fastened by means of studs, avoiding the costly and sometimes inconvenient use of laths and frames. However, because of their structure, they are apt to produce appreciable quantities of siliceous dusts and other particles which pass into the air in the course of time and thus constitute a potential source of danger to the health of personnel, in addition to affecting the operation of equipment. Therefore, it is necessary to consider the possibilities of providing some suitable protection.

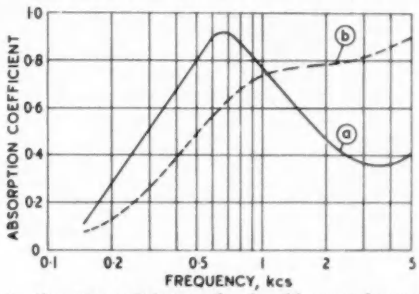

Fig. 1. **Absorption coefficient as a function of frequency for panels of bakelized glass wool, (a) with a surface layer of varnish, and (b) without varnish.**

One of the most practical methods immediately available is the application of a layer of protective varnish to the exposed surfaces. This surface layer, however, modifies the acoustic characteristics of the material, which are then no longer the same as those of a simple porous material. In fact, the layer of varnish on the surface of a porous body behaves as an additional mass, while the porous material itself and the air enclosed act as a spring. Their combined effect is a reduction in absorption capacity at the highest frequencies, owing to the covering of varnish, whereas at medium and low frequencies a considerable increase in absorption capacity may be obtained as a result of the internal resonance of the panel system (diaphragm action of the varnished surface).

Similar results are obtained when the material is covered with thin sheets of paper or plastic material. The panel material, besides being porous, should also, of course, have the necessary amount of elasticity to enable the surface covering to vibrate. This is the case with glass fibre but, with less resilient materials, the additional effect of the varnish or other surface covering may be less noticeable or even non-existent.

In order to obtain numerical data, it was decided to investigate in the first instance panels of bakelized glass fibre having a thickness of 20 mm and a density of 0·065 gm/cm³. The absorption coefficient was measured in an echo chamber on panels with and without the layer of varnish on the outside surface. The corresponding results are given in Fig. 1. These curves show that the varnish increases absorption in the range of low and medium frequencies; at 400 cps, for example, the absorption coefficient increases from 0·4 to 0·7.

The acoustic behaviour of the material was further investigated by means of stationary waves in a Kundt tube. The results of these measurements differ from those previously obtained, because the incident sound waves are perpendicular to the test surface, but the

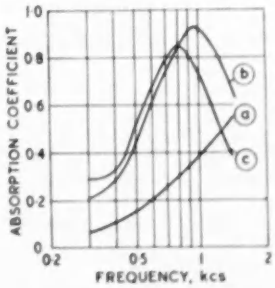

Fig. 2. **Absorption coefficient as a function of frequency, with normal incidence, for samples of bakelized glass wool, as determined by the stationary-wave method.**
(a) Unvarnished surface.
(b) Surface with one layer of varnish.
(c) Surface with two layers of varnish.

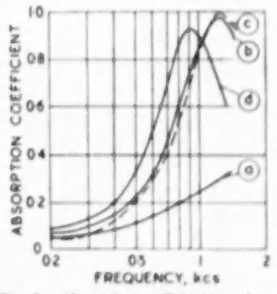

Fig. 3. **Absorption coefficient as a function of frequency, with normal incidence, for samples of rock wool, as determined by the stationary-wave method.**
(a) Unvarnished surface.
(b) Surface with one sheet of paper.
(c) Surface with one layer of varnish.
(d) Surface with two layers of varnish.

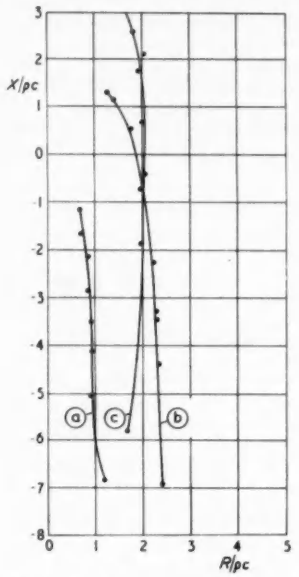

Fig. 4. Graph of $X/\rho c$ as a function of $R/\rho c$, for samples of bakelized glass wool, under the conditions given in Fig. 2.

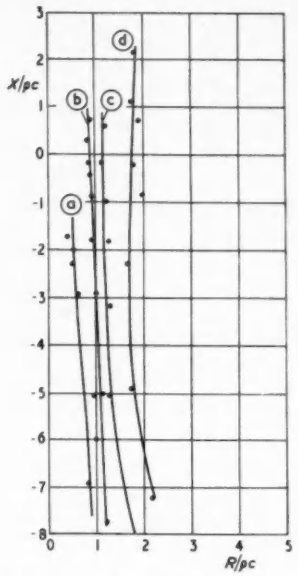

Fig. 5. Graph $X/\rho c$ as a function of $R/\rho c$, for samples of rock wool, under the conditions given in Fig. 3.

method has the advantage of allowing measurements to be made on small samples, and also permits evaluation of acoustic impedance, giving further information on the physical behaviour of the material.

Fig. 2 shows the variation in the absorption coefficient as a function of frequency for the material considered, on the basis of these measurements. The curves give the absorption coefficient for the bare material, as well as for material with one or two layers of varnish on its outer surface ; here again, there is an increase in the absorption coefficient at low frequencies for the covered material, as compared with the bare material ; moreover, as expected, the frequency at which maximum absorption is obtained is decreased when the material is covered with two layers of varnish, i.e., when it carries a greater mass per unit area. Fig. 3 shows similar results obtained by the stationary-wave method for another porous material, i.e., rock wool, with a thickness of 20 mm and a density of 0·08 gm/cm^3, using coverings of various types.

The additional mass of the surface layer makes the panel behave as a resonant system. The resonance effect can be very small for very rigid materials, and it has, in fact, been found that for certain materials (generally with a low absorption coefficient) the addition of a superficial protective layer causes no appreciable changes in acoustic properties.

As previously mentioned, the variation in acoustic impedance was also determined. If c is the speed of sound, ρ is the density of air, and R and X are respectively the acoustic resistance and reactance of the material, $R/\rho c$, in the case of the first untreated material (i.e., bakelized glass wool), was found to be nearly constant for all frequencies and approximately equal to unity, while $X/\rho c$ was found to vary between about -1 and -7, as shown in Fig. 4. In the analogous electrical circuit, X can be regarded as a pure capacitance. With one layer of varnish, X also includes an equivalent inductance (representing the mass of the varnish), and the corresponding curve in Fig. 4 is again nearly vertical, though, for increasing frequencies, $X/\rho c$ passes through zero (at resonance) up to positive values, while $R/\rho c$ has at the lower frequencies a practically constant value of about 2·0, tending to decrease at the higher frequencies. For two layers of varnish, the curve is fairly similar, but passes through zero at a somewhat lower resonant frequency and reaches higher positive values.

Fig. 5 shows the results obtained in the case of rock wool for the untreated material, and for the material covered with a layer of paper, with one layer of varnish, and with two layers of varnish.

In a second part of the investigation, stationary-wave tests were carried out on multiple panels, formed by superimposing several layers of the same material with intermediate surface coverings. The results for single, double, and triple panels of bakelized glass wool, with and without varnish at the intersurfaces and the outside surfaces, are shown in Figs. 6 and 7. From Fig. 7, it will be seen that the panels without varnish have no resonance peaks.

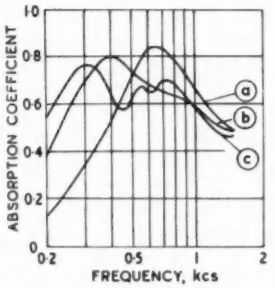

Fig. 6. Absorption coefficient as a function of frequency, with normal incidence, for bakelized glass-wool panels, as determined by the stationary-wave method, each panel having a layer of varnish on one of its surfaces.
(a) One panel only.
(b) Double panel.
(c) Triple panel.

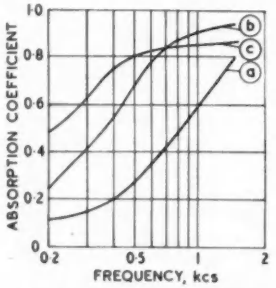

Fig. 7. Absorption coefficient as a function of frequency, with normal incidence, for unvarnished bakelized glass-wool panels, as determined by the stationary-wave method.
(a) One panel only.
(b) Double panel.
(c) Triple panel.

For rock wool the general pattern of the results is similar. Composite panels with one to six layers of glass wool, with and without varnish, were tested, and the highest absorption was coefficient again around 0·8.

In conclusion, it may be said that protective coverings on sound-absorbent materials reduce their absorption characteristics at high frequencies and increase them at low frequencies. This is not always an advantage, since the required characteristics depend on the acoustic features to be corrected in each case. However, by suitable distribution of the materials used, it should be possible to obtain the desired conditions of attenuation, combined with suitable protection of the porous materials used.

High-Vacuum Electron-Beam Fusion Welding

By W. L. Wyman. (From *The Welding Journal*, Vol. 37. No. 2, February 1958, pp. 49s–53s, 13 illustrations.)

The requirements for the large-scale fabrication of materials such as zirconium, titanium, molybdenum, and their alloys have introduced problems in joining which have resulted in a major evaluation of the welding techniques suitable for application on these materials. Much effort has been extended to the application of the inert-gas-shielded arc-welding processes for joining the materials, and the results of this work have been very satisfactory for many applications. The efforts along this line have also indicated several shortcomings of these processes, opening up the field for the development of new or improved processes. As a result, a new process has been developed which offers several advantages.

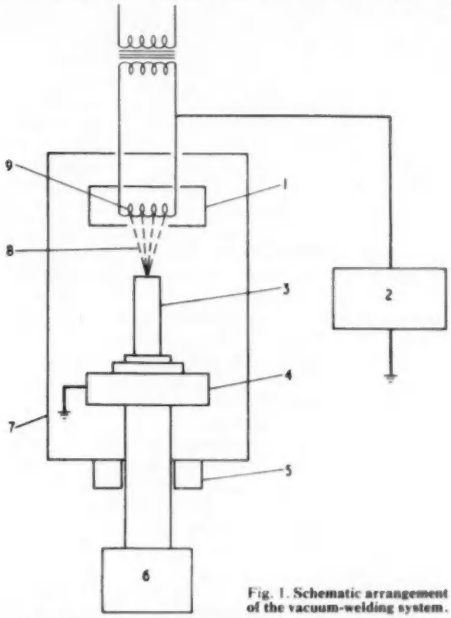

Fig. 1. Schematic arrangement of the vacuum-welding system.

In the new process, known as high-vacuum electron-beam fusion welding, the two pieces to be fusion-welded are bombarded by a beam of electrons in a high-vacuum chamber. The basic elements of the process are shown schematically in Fig. 1, in which a large number of electrons are emitted from a tungsten cathode, a potential from a high-voltage supply (2) between the cathode and the plate being used to accelerate the electrons from the electron-gun assembly (1). A focusing system forms the electrons into a beam (8) which impinges on the workpiece (3), mounted on a chuck (4) and capable of rotation by a variable-speed drive (6) through a vacuum seal (5) in a vacuum chamber (7). The vacuum chamber is connected to pumping equipment capable of maintaining a pressure of at least 5×10^{-3} mm Hg.

The tungsten filament (1), in the form of a spiral wire, is heated to above 2600°K, and thermionic emission of electrons in large quantities takes place from its surface. For a current of 250 mA, approximately $1{\cdot}5 \times 10^{18}$ electrons per second are emitted from this filament. The normal working range of voltage for this process is from 1,700 to an estimated 15,000 V, the restriction on the latter voltage being placed as the upper limit of usability before hard X-rays, capable of penetrating the walls of the vacuum chamber (7), are generated. Nevertheless, higher voltages could be used, with proper radiation shielding, though it is doubtful whether any material improvement would be obtained. To cover all applications, it is considered that the high-voltage supply system should have a power output from 10 to 2000 mA.

Focusing of the electron beam (8) is essential, so as to ensure that the concentration of electrons striking a small localized area to be welded is sufficient to raise the temperature of this area to the melting point. As the material is melted, the two edges flow together and, by progressively moving the pieces to be joined beneath the beam, a fusion weld results. The beam spot found most suitable for this work ranges from $\frac{1}{16}$ in. in diameter for thin material (0·005 in. in thickness) up to $\frac{3}{16}$ in. in diameter for heavy material ($\frac{1}{2}$ in. in thickness).

Characteristics of the Process

The new process differs from the normal fusion-welding process in several ways. The fact that the welding operation must be effected in a vacuum chamber introduces certain advantages, as well as a number of disadvantages, the most important of the latter being that, after evacuation, only a limited amount of adjustment of the physical location of the components is possible. At the same time, however, the requirement of a sealed chamber obliges any work set up to be welded almost completely automatically, so that the problem of the possibility of operator variables affecting product uniformity is greatly reduced and the benefits of automatic welding are obtained.

The process has a built-in protection against any weld being made under conditions of poor atmospheric protection. A high-voltage arc discharge will occur at pressures above about 5×10^{-3} mm Hg. This restricts welding until a sufficiently low pressure (5×10^{-4} mm Hg) is reached, so that a minimum atmospheric purity of 99·999987% surrounds the parts to be welded, which compares with welding-grade helium with a minimum purity of approximately 99·99%, and welding-grade argon with a minimum purity of approximately 99·95%. The high purity necessary for this process assures that one of the variables, i.e., gas shielding, normally used in fusion welding of the reactive materials, is eliminated. The atmosphere of extremely high purity completely surrounds the parts to be welded, eliminating the requirements for rapid-quenching jigs to limit the time that the weld area is at elevated temperature and, therefore, subject to contamination by gases. The purity of 99·999987% is the upper limit of working range successfully used to date. However, by using lower pressures, purities of the order of 99·99999987% can easily be obtained.

Another very important characteristic of this process is the heat input into the parts to be welded. The energy input into the weld area is very soft, i.e., no apparent force is exerted on the molten puddle. As a result, no crater can be observed at any time, and the weld stopping point is difficult and sometimes impossible to detect when a cylindrical weld is completed. This soft heat input makes the control of welds on thin material, e.g., 0·005 in., very easy. No force tends to drive through and blow holes in the workpieces and the power into the weld can

be controlled over the full range of from zero up to the maximum desired wattage. No appreciable surface disturbance or contour change is noted when comparing the fusion area with the adjacent base metal, and very wide fusion zones with respect to the workpiece-material thickness can be carried, ensuring smooth welds.

The effect of contamination from the welding equipment is not encountered with this process. Nothing in the system breaks down during welding, and the electrons which make up the energy source do not react with the molten puddle. Any stray ions that may be formed as a result of an electron colliding with a molecule of residual gas would carry a plus charge in most cases, and as a result would be attracted to the negative cathode instead of the workpieces. This factor tends to increase the potential purity in the weld area over the actual calculated value. A pure heat source of this type, coupled with the extreme purity of the surrounding atmosphere, results in a method ideally suitable for the melting of the reactive metals without danger of contamination.

During the welding operation, the only visual effect is the melting of a localized area beneath the electron beam. The electron beam itself cannot be seen ; only the effect is detectable. The process can be viewed through a welding glass, to discern the condition of the molten pool. As mentioned before, the puddle does not appear disturbed in any way and the heat input into the workpieces is very smooth. Control of the weld can be accomplished either by visual observation and adjustment or by automatically controlled power input into the weld. By control of the focus of the electron beam, the melt area can be made larger or smaller, as desired, and this control of the melt area is very helpful in welding thin material, where an extremely small melt area is desired. The penetration pattern is controllable and is a function of the power into the weld and the travel speed. This penetration can be controlled to yield 100% or anything less, as desired, the only requirement being a sufficiently large high-voltage power supply to handle the thickness of material.

Most of the work to date has been directed towards the development of welding procedures for Zircaloy-2, which is an alloy of zirconium containing 1·5% tin, 0·12% iron, 0·10% chromium, and 0·05% nickel. However, most of the common metals used to-day can also be welded satisfactorily, e.g., tungsten, molybdenum, titanium, nickel, and several stainless-steel alloys. In the beginning, a notable exception was aluminium, which gave welds which did not compare in quality and appearance with those made by more conventional processes. Now, however, recent work has led to a suitable combination of factors which make it possible to weld aluminium alloys with ease.

The process has been used on many joint designs, including butt joints, lap joints, edge joints, plug welds, and fusion spot welds, and also to join thin sections to heavy sections. The application of this process follows the same general pattern that would be used in inert-gas-shielded tungsten-arc welding, and can be considered an all-position process. The process has been used to fuse two surfaces together, and no attempt has been made to add filler wire to the joint, although this could be done quite easily with the proper vacuum chamber.

Welds made with this process have a uniform width of fusion and a very smooth, clean, mirror-like surface. The root side of the weld appearance is the same as the face side, and no crater or other surface disturbance is detectable.

Microsections of many welds were inspected to determine the weld quality and the fusion pattern. In no case, on either stainless steel or Zircaloy-2, was weld porosity observed. The quality of the weld was of the highest order, and penetration was satisfactory.

The observed quality of welds from the standpoint of surface and microstructure was superior to welds made by conventional processes on these materials.

Properties of Welds

In all cases in this report, the mechanical and other properties of welds made with this process are restricted to Zircaloy-2. The factors investigated were tensile strength, ductility, structure, hardness, and corrosion rates. Comparisons between vacuum welds and the as-received material, 13% cold-worked, showed that the welded material had a tensile strength of 92,900 psi, as against 96,000 psi for the as-received material, this slightly lower strength possibly being due to the effects of annealing in the fusion zone. This would also account for the slightly higher reduction in area of the welded material (38·7%, as against 36·2%).

In the case of controlled bend tests, it was difficult to obtain the exact point of failure, as indicated by face cracking. The weld area had approximately the same tensile strength and ductility as the as-received material.

A plot of hardness as a function of weld position indicated that the molten weld puddle was not contaminated during the welding cycle to such an extent as to cause increased hardness in that region. The fusion area and the heat-affected zone near the fusion line both had the same hardness.

The weld area and the heat-affected zone exhibited the characteristic transformed beta structure of zirconium quenched from above the alpha-beta transformation temperature. The large grain size developed in fusion-welding zirconium alloys should be held to a minimum by welding as rapidly as possible.

Tests to determine the effect of welding on the corrosion resistance of Zircaloy-2 to water at 686°F are now in progress. The results after 70 days show no detectable differences in the corrosion rates between welds, heat-affected zones, or as-received material.

Conclusions

From the results of this investigation, the following conclusions have been drawn :—

(1) This process makes possible fusion welding with no contamination introduced into the welding area by the welding process itself and makes possible production welding in atmospheres of extreme purity.

(2) Containers can be fusion-welded in such a way that the residual gas in the vessel is very small.

(3) For metals which react with gases at elevated temperature and become contaminated, the process offers a means of welding which assures no detectable absorption.

(4) The process is suitable for production welding on certain applications, and under certain conditions is cheaper than conventional welding methods.

(5) The potential uses and scope of this process have not been evaluated, but several applications become immediately apparent. For example, the study of welding effects on reactive materials without the masking effect of gas contamination will make possible a more accurate and complete determination of the effects of welding. This type of study should lead to a better understanding of the requirements for joining several of the new materials, such as zirconium, titanium, etc.

Properties and Applications of "DU" Unlubricated P.T.F.E.-Type Bearings

By D. C. MITCHELL and D. A. STARKEY.*

IN many industrial and domestic machines it is often inconvenient, undesirable, or even impossible to use bearings of the conventional oil-lubricated type. Originally, this situation was met by using either graphite bearings or complicated and costly assemblies designed to ensure that the bearings were kept remote from areas likely to cause trouble. More recently, however, a number of plastics has been developed and suggested for use in such applications. Of these, the most notable is polytetrafluoroethylene (P.T.F.E.), outstanding features of which include extreme chemical inertness, complete resistance to solvents and water, high transition temperature, and marked anti-stick and anti-friction properties.

In its original form, the application of P.T.F.E. has been limited to bearings operating at very low loads and speeds, because of its relatively poor mechanical properties and high thermal expansion, associated with low thermal conductivity. Difficulties in this connection, insofar as use of the plastic in bulk is concerned, have been overcome by impregnating it in a porous sintered bronze.

After considerable research, the Glacier Metal Company has developed a new unlubricated bearing material consisting of a steel backing onto which is sintered a thin lining of spherical bronze (89%Cu/11%Sn), impregnated with a mixture of P.T.F.E. and lead and having a thin surface layer over the tops of the bronze spheres of the same P.T.F.E./lead mixture. The P.T.F.E./lead impregnated bronze consists of two completely interlocking sponge-like networks, one of the bronze and the other of the plastic with its lead filler. The steel backing to the bearing is electroplated with a thin layer of tin, so as to protect it from normal atmospheric corrosion.

This material is designated "*DU*", and it is with the design of bearings made from it that this article is concerned. *DU* is produced in strip form and made into bearings which are prefinished and which therefore do not require to be machined before use. Some typical standard products made from *DU* are shown in Fig. 1.

MECHANICAL AND PHYSICAL PROPERTIES OF *DU* BEARING MATERIALS

The yield strength in compression of *DU* is 23 tsi, its coefficient of linear expansion is 15×10^{-6}/°C, and its thermal conductivity 0·1 cal/sec cm °C. The diamond pyramid hardness of the lining, with a 30-kg load, is 30 to 35 DPN. It will thus be seen that these properties are almost entirely those of the metals used in the bearing material. For instance, the similarity between the thermal expansion and, to a lesser extent, the thermal conductivity of *DU* and those of steel or a number of other metals means that, in practice, no trouble will arise from differential expansion between the bearing and a steel housing or shaft.

The compressive strength of *DU* is high because of the support given to the combined bronze and P.T.F.E/lead lining by the steel backing incorporated. As an example, it may be mentioned that, in one application of *DU*, a single bush mounted in a steel roller was required to carry the full weight of a large jet engine while the latter was being mounted in and removed from an air-frame, but no trouble was experienced, although the pressure on the bush in this case was estimated to be 18 tsi, and ball races had previously failed because of excessive load. Nevertheless, it is generally desirable that the maximum bearing load be limited to 4 tsi since, above this loading and with continuous movement, the lining is liable to fail through fatigue of the sintered bronze.

WEAR AND FRICTION

All plain bearings operating under sparse or unlubricated conditions wear during use, but *DU* bearings follow a pattern which is more akin to that of oil-lubricated bearings. When these bearings are first put into service, bedding-in takes place, causing the loss of the 0·0008-in. surface layer of P.T.F.E. and lead. This surface layer coats the mating surface with a very thin film of the P.T.F.E./lead mixture, and an equivalent thin film is retained on the bearing surface. These thin films, present after bedding-in, are both considerably less than 0·0001 in. in thickness, so that, during the bedding-in operation, the excess surface layer is shed in the form of flakes of material from the assembly. Bedding-in, which takes place under full operational conditions, is usually completed in about 20 hr, though it may, under conditions of light load and/or low speed, extend to as long as 50 to 100 hr. Comparative photomicrographs of sections through *DU* bearings, showing the bearing surfaces before and after bedding-in, are reproduced in Fig. 2, in which the light areas correspond to the sintered-bronze matrix and the dark areas to the P.T.F.E./lead impregnation.

After the wear occasioned by bedding-in, little further wear of the bearing occurs during its life, as shown in Fig. 3. Even under the most arduous conditions, wear is extremely small, being of the order of 4×10^{-7} in. per hour of operation. With correct operating conditions,

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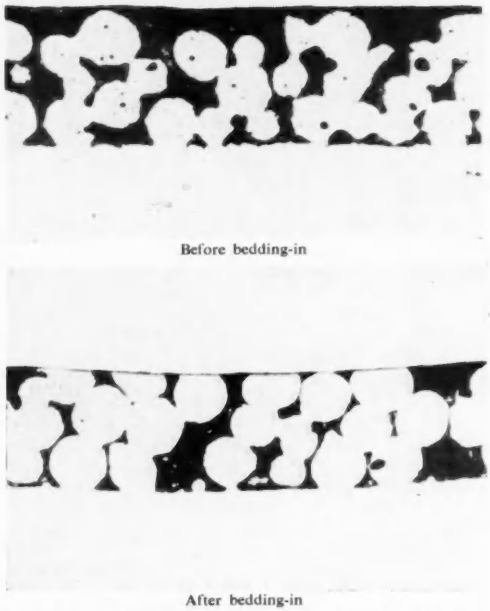
Fig. 1. Typical standard products made from *DU* material.



Before bedding-in

After bedding-in

Fig. 2. **Comparative photomicrographs of sections through *DU* bearings showing bearing surfaces before and after bedding-in. (×100).**

laboratory and field tests with mild-steel mating surfaces have shown no detectable wear of the steel, even after several thousand hours of operation.

The loss of flakes of P.T.F.E./lead from the surface layer during the very early stages sometimes leads to a belief that running conditions are too arduous and that this rate of wear will continue. As shown in Fig. 3, this belief is definitely erroneous. It is true that the loss of the surface layer can occasionally be troublesome in the case of bushes which are totally enclosed, inasmuch as the flakes tend to congregate in one area of the bush and to form a wedge which occupies the bearing clearance space and thus gives rise to incipient seizure. However, with bearings which have at least one open end or other free space where these flakes can congregate under the force of gravity, no trouble is experienced.

With regard to the friction of *DU* bearings, laboratory investigations with loads varying from 10 to 1500 psi and speeds from 40 to 1000 fpm have shown that the coefficient of friction ranges from about 0·10 to 0·16, with an average value of about 0·13. These values were obtained from continuous torque measurements on bearings during investigations of their long-term bearing properties and are about the same as those obtained from similar but shorter tests on conventional bearing materials with boundary oil lubrication. Within this range, it was established that the coefficient of friction of *DU* was independent of load and speed.

At very low speeds, in the range between 1 and 20 fpm, the coefficient of friction is only about 50% that at the higher speeds. There is also some evidence to show that, at very high loadings (in the region of several thousand pounds per square inch), the coefficient of friction is somewhat less than it is at the lower loads. No evidence of stick-slip was found in any of the friction measurements carried out on *DU*.

In industrial equipment, it is difficult to obtain a real assessment of the coefficient of friction, but values ranging from 0·01 to 0·20 have been reported for *DU* bearings.

Dimensions Required to Withstand a Given Load and Speed

As it is only natural that, in any given application, bearing assemblies will be designed to be as small as possible, it follows that the bearings will operate near to their limit, with as small a safety margin as can be tolerated.

In considering the recommended loads and speeds which can be used with a given bearing area, it is assumed initially that the bearings will operate with a mild-steel shaft which has been reasonably well finished, e.g., by grinding, and under completely unlubricated and uncooled conditions. The modifying effects of other conditions on performance will be discussed later.

The permissible loads and speeds which can be used depend on the bearing under consideration, four common types being as follows :—

(1) Cylindrical bushes in which the shaft oscillates through a limited angle.
(2) Cylindrical bushes in which the load rotates continuously relative to the bush.
(3) Cylindrical bushes in which the load is stationary relative to the bush, i.e., unidirectional, and the shaft rotates continuously.
(4) Flat annular thrust washers.

The *PN* values corresponding to each of the four types of bearing classified above, for 1000 hr continuous operation without failure, and for 10,000 hr without failure, are shown in Table I. In all cases it is assumed that the mating surfaces involved are of mild steel (hardness = 160 DPN), having a surface finish smoother than 20 micro-inches (r.m.s.). For cylindrical bushes, the pressure *P* on the bearing [psi] is taken as the total applied load [lb] divided by the projected area (diameter × length) of the bush [sq. in.]. For cylindrical bushes with an oscillating shaft, the rotational speed *N* is equivalent to the number of cycles per minute of the shaft.

Table I : *PN* Values for *DU* Bearings with Mild-Steel Shafts

Type of Bearing	1000 hr	10,000 hr
(1) Bush with oscillating shaft	180,000	155,000
(2) Bush with rotating load	150,000	130,000
(3) Bush with unidirectional load	100,000	75,000
(4) Flat annular thrust washers	75,000	40,000

In the case of strip material used as a slide, *N* can be taken as the number of sliding cycles per minute, the corresponding *PN* values being 40,000 for 1000 hr and 20,000 for 10,000 hr.

By dividing the appropriate *PN* value by the known rotational speed *N*, the permissible bearing pressure *P* can be ascertained. The bearing area required can then be found by dividing the total applied load by the pressure. All that is then necessary is to decide on the diameter and length of the bush. With bushes it is generally more convenient to choose the dimensions in such a way that the length/diameter ratio of the bearing lies between 0·5 and 2·0, but this rule is by no means rigid, as no effect on performance directly attributable to this ratio has yet been found.

As a typical example of the application of *DU* bear-

ings and the use of Table I, consider the case of a domestic washing-machine in which some of the bearings cannot be of the oil-lubricated type, as they are required to operate in occasional contact with water containing detergents. If the machine has a belt-driven impeller operating at 1500 rpm and carried in a bush which has to withstand a load of up to 32 lb, owing to belt pull, and a dead load of 2 lb, owing to the weight of the impeller, the total load on the bearing is 34 lb. As the machine is intended for domestic use, 1000 hr of continuous operation is equivalent to between 10 and 20 years service, so that the values given for 1000 hr in Table I can be used. Here, it will be seen that, when the load is unidirectional to the bush, as it is in this instance, the pressure corresponding to a speed of 1500 rpm is 100,000/1500 = 67 psi approximately. As the total load is 34 lb, a projected bush area of about 34/67 = 0·5 sq in. approximately is required. In actual fact, a bush of $\frac{5}{8}$ in. diameter and 1 in. length, giving a bearing area of 0·625 sq in., is used in this particular application.

In addition, the impeller of this washing-machine is subject to a thrust which is estimated to be about 10 lb. A thrust washer is therefore required, and from the corresponding *PN* value of 75,000 in Table I, the pressure corresponding to a speed of 1500 rpm is 50 psi, so that a washer with an area of 0·2 sq in. is needed. As the shaft diameter of the bush is $\frac{5}{8}$ in., the internal diameter of the washer must be somewhat larger, and in actual fact a washer of $\frac{3}{4}$ in. internal diameter and 1 in. external diameter was chosen in this particular instance.

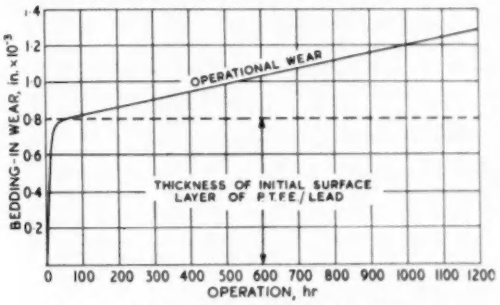


Fig. 3. **Typical wear/time relationship for *DU* materials.**

In normal engineering applications, it is unlikely that bearing pressures will exceed 10,000 psi and rotational speeds 10,000 rpm. These values, should not, however, be interpreted as representing the upper limits of load and speed for *DU* bearings. Thus, for example, in addition to the application of a *DU* bearing for taking the full weight of a jet engine, already mentioned, in which the bearing had to withstand a load of about 40,000 psi, a similarly heavily loaded bearing has been used in an aircraft undercarriage, involving pressures during landing of up to 30,000 psi. Another example is concerned with the application of *DU* bushes to high-speed textile machinery used for processing continuous synthetic filaments. In this case, pairs of *DU* bearings, $\frac{3}{8}$ in. in diameter and $\frac{3}{4}$ in. in length, are used with shafts rotating at 50,000 rpm. In very high-speed applications such as this, it has been found that *DU* bearings tend to operate on a hydrodynamic film of air, so that the permissible *PN* values can be even higher than those given in Table I.

Effect of Clearance on Performance

Laboratory tests on bearings and practical experience have shown that, with diametral clearances up to 0·003 in., there is very little, if any, change in performance with change in clearance.

DU bushes are manufactured in such a way that, when inserted into a reasonably rigid housing produced to the *H*6 limits in BSS. 1916 : 1953, they will have an adequate interference fit. In addition, if bushes are used in conjunction with shafts produced to the *h*6 limits given in BSS. 1916 : 1953, they will have an adequate operating clearance, as shown in Table II, in which the mean clearance and the variation in this clearance are given, the latter being expressed as 95% confidence limits. It will be seen that, with decreasing bush diameter, there is a decrease in initial operating clearance, to allow for the increased accuracy of smaller bushes.

Table II : Initial Clearance of *DU* Bushes

Bore of Bush [in.]	Mean Initial Diametral Clearance [in.]	Initial Clearance Range [in.]
$\frac{3}{8}$ to $\frac{1}{2}$	0·0009	± 0·0008
$\frac{5}{8}$ to 1	0·0012	± 0·0009
$1\frac{1}{4}$ to $1\frac{1}{2}$	0·0015	± 0·0011
$1\frac{3}{4}$ to 2	0·0018	± 0·0014

When considering Table II, it should be understood that the mean diametral clearance is the clearance present in the bearing before use. To this must be added the increase in clearance caused by the loss of the surface layer (0·0008 in.) to obtain the operating clearance present at the end of the bedding-in period. As an example, for bushes of $\frac{3}{8}$ to 1 in. bore, with an initial mean clearance of 0·0012 in., the operating clearance after bedding-in will be about 0·0020 ± 0·0009 in. The upper limits of clearance are sometimes in excess of those which can be tolerated in a number of industrial applications where very precise control of bearing clearance is essential. For example, with bearings in artificial limbs, it was found that users could readily detect and experience discomfort with a bearing clearance in excess of about 0·002 in. In such applications, it is therefore necessary to fit the shaft selectively to a bush of the appropriate size.

Choice of Shaft Materials

The *PN* values in Table I are based on the use of plain mild-steel shafts, having a hardness of 160 DPN, with *DU* bearings. If a higher permissible *PN* value is required from a bearing of given dimensions, this can be achieved with the use of a shaft material having a hardness which is greater than that of mild steel. In this connection, it should be noted that, although the permissible *PN* value increases when shaft hardness is increased, no further improvement is obtained after a hardness of 600 DPN is reached.

As already mentioned, the *PN* values given in Table I for 1000 and 10,000 hr operation are based on the use of mild-steel shafts with a hardness of 160 DPN. For purposes of comparison, Table III shows the permissible *PN* values with hardened-steel shafts of 300 and 600 DPN, used in conjunction with similar types of bearings.

Table III : *PN* Values for *DU* Bearings with Hardened-Steel Shafts

Type of Bearing	STEEL (300 DPN)		STEEL (600 DPN)	
	1000 hr	10,000 hr	1000 hr	10,000 hr
(1)	185,000	160,000	200,000	175,000
(2)	160,000	140,000	180,000	160,000
(3)	115,000	85,000	150,000	110,000
(4)	80,000	45,000	90,000	60,000

In the case of strip material used as a slide, in conjunction with hardened steel of 600 DPN, the corres-

ponding *PN* values are 45,000 for 1000 hr and 25,000 for 10,000 hr.

The advantages to be derived from the use of hardened-steel shafts have been demonstrated in the case of bearings for electric starter-motors in automobiles, in which it was found that the porous bronze bearings originally used were failing, owing to insufficient impact strength, and that the oil from these bearings was tending to interfere with satisfactory operation of the motor. In this case, a life of about 1000 hr was considered desirable, and the *PN* value was estimated to be about 140,000 for bearings of the original dimensions, which could not conveniently be altered, as modifications of this type would have entailed alterations to several other components. As the bearings in question were subjected to a unidirectional load, i.e., they were of type (3), it can be seen from Table III that the only method of ensuring satisfactory operation within the limitations imposed was the use of a hardened-steel shaft.

In many applications, mild-steel or hardened-steel shafts can be utilized, but in some cases an alternative material may be preferred. The choice of shaft material will usually be determined by the corrosive nature of the atmosphere in which the bearings are required to operate. When using unlubricated bearings, the absence of lubricant naturally implies a lack of corrosion protection for the shaft. Tests have been made with mild-steel shafts protected against corrosion by electrodeposited films of cadmium, tin, lead, nickel, and chromium, and it has been found that none of these coatings reduces the *PN* values below those given in Table I for mild steel. In fact, chromium-plated mild steel performs better than unplated mild steel.

If plated steel is unacceptable, then anodized aluminium, anodized aluminium alloys, or stainless steel (preferably of the austenitic type) can be used. Copper-base alloys are best avoided, as they are liable to suffer from incipient seizure when they come into contact with the bronze matrix of the *DU* material. The *PN* values given in Table I for mild steel are also applicable in the case of anodized aluminium alloys, cast iron, and stainless steel.

Effect on Bearing Performance of Shaft Surface Finish

With regard to the performance of *DU* bearings, the surface finish of the mating member is not critical, as the surface layer on these bearings is used to fill up the roughness in the mating member. It has been shown that, provided the finish is better than about 20 micro-inches (r.m.s.), e.g., as given by grinding or fine-turning and polishing with emery, performance is unaffected by variations below this value. Above about 20 micro-inches, however, the permissible *PN* values should be reduced by about 20%. In the majority of cases arising in practice, no difficulty has been experienced in obtaining shafts with an adequate surface finish.

Bearing Misalignment

All plain bearings, including *DU* bearings, perform less satisfactorily when misalignment exists between the bearing and the shaft. If there is excessive deflection of the shaft over the length of a *DU* bearing, or if the axis of the bore of the bush and of the shaft are at an angle to one another, premature failure can occur, despite the fact that the apparent *PN* value for the bearing is within the capacity of the material. The reason is because, as the angularity of the shaft increases, so the amount of bearing surface coming into contact with the shaft decreases. As a result, the pressure on the part of the bearing actually carrying the load is considerably larger than anticipated, giving rise to premature failure.

Laboratory tests have demonstrated that, if either the misalignment between the axes of the shaft and the bush over the length of the bearing, or the deflection over the length of the bearing, is less than 0·0008 in., no reduction in the permissible *PN* value is required. In cases where the relative angularity of the shaft and bush are greater than 0·0008 in., the *PN* value should be calculated with the use of only that part of the length of the bearing which will actually be in contact with the shaft after bedding-in.

It should always be borne in mind that, when designing for the use of *DU* bearings, misalignment and edge loading must always be kept to a minimum. In fact, misalignment has proved to be one of the most frequent sources of trouble experienced in the application of these bearings. For example, in one textile application, involving spinning frames with bearings every few inches along the 60-ft length of a 1-in. diameter shaft, it was virtually impossible to ensure that these bearings were all in line over the entire length, and that the shaft would not deflect over this distance. In this particular application, the trouble was overcome by the use of self-aligning housings to carry the bushes.

Operational Temperature Range

Successful operation of *DU* bearings is reported at temperatures between —200 and + 280°C, and within this range it has been established that the *PN* values which can be used are completely independent of operational temperature, so that the pressure and speed relationships given can safely be used between these extremes. It should also be noted that these bearings will operate satisfactorily even when subjected to sudden and severe temperature fluctuations.

Typical applications of *DU* bearings in this connection include their use in rollers and linkages, etc. for large baking ovens, in aircraft jet-engine control systems, in aircraft undercarriage components, control rods, actuator mechanisms, and radar scanning devices, and in refrigeration plant and in valves handling compressed gases.

Effects of Dirt and Grit

The fact that *DU* bearings are unlubricated is an advantage, insofar as dirt and grit are concerned, inasmuch as oil is well-known as an efficient means of picking up and trapping dirt. In actual fact, no great precautions need be taken with *DU* bearings to prevent the ingress of dirt. Nevertheless, where exceptionally large quantities of abrasive material are present, it is advisable to fit some type of rotating seal ; otherwise, there is the possibility that abrasive material may be carried round in the bearing, cutting away the thin films of P.T.F.E. and eventually leading to rapid failure.

Tests on *DU* bearings have shown that they perform satisfactorily in dirty atmospheres. Thus, they have been used successfully in a wide range of applications, including tea, sugar, and detergent packing, in textile machinery, and in the manufacture of cigarettes. They have also been used under arduous conditions in cement- and concrete-mixing machinery, in roller conveyors in foundries, and in support rollers for belt conveyors in mines.

Operation in Liquids

In applications involving the use of *DU* bearings submerged in water or other liquids, the loads and speeds at

which the bearings can be operated depend not only on the dry bearing properties of the material but also on the capacity of the bearing to function under hydrodynamic conditions.

It has been found that, even under the most adverse conditions, the bearing can be treated in the same way as a dry *DU* bearing. In general, however, an attempt should be made to induce in the bearing a hydrodynamic film, which will probably improve significantly its load-carrying capacity.

In normal *DU* bearings, the thin overlay plating of tin is sometimes insufficient protection during operation in corrosive fluids. In such cases, the bearing can be provided with additional protection by electroplating. Thus, if a 0·0005-in. layer of either nickel, silver, chromium, lead, cadmium, or even extra tin is plated onto the bearing, the desired protection should be achieved in most cases. Incidentally, when any of these metals are plated onto the steel backing of the bearing, a small amount of the metal will also be plated into the bore of the bush. Tests have, however, shown that this small amount of metal exercises absolutely no detrimental effects on performance.

Applications of *DU* bearings under submerged or partly submerged conditions include their use in gear pumps, and pumps for petrol, paraffin, and other solvents. Another application has been in rollers operating below the level of an acid plating solution. In this case, they were first plated with lead and then assembled, and no evidence of corrosion on the backs of the bearings has so far been observed. In still another application, concerned with the wringer of a washing-machine, in which the bushes were constantly subjected to water containing detergent, the risk of corrosion was eliminated by providing the steel backing of the bearing with an increased layer of tin, in this case 0·0004 in. in thickness.

Potential Applications

In general, it may be said that *DU* bearings have a wide range of applications in all cases where the use of oil-lubricated bearings is either impossible (e.g., in trolleys used in vapour-degreasing plant, or under submerged conditions) or undesirable (e.g., in domestic equipment, including vacuum cleaners, refrigerators, washing machines, and mixers), either because users cannot be relied upon to oil the bearings periodically or because the use of oil may give rise to contamination or marking.

In addition to the applications already mentioned in this article, potential applications include their use in numerous automobile components and accessories, including starter-motors, generators, distributors, windscreen wipers, water pumps, heating fans, steering-columns, and window mechanisms. Successful tests have been carried out in connection with their use in a number of ball suspension joints, track-rod bearings, universal coupling bearings, linkage arms, control rods, brake pivot points, and steering mechanisms.

In aircraft, *DU* bearings have also been successfully used, among other applications, in cabin equipment for such items as adjustable seats and air-pressurizing equipment, while in the field of mechanical handling, applications range from large stacker trucks and trolleys to conveyor rollers and push-pull turn-over mechanisms associated with automation.

GERMANY

Ultrasonic Testing of Insulating Materials used in Transformers

By R. Braun. (From *Der Maschinenschaden*, Vol. 31, No. 1/2, February 1958, pp. 11–13, 4 illustrations.)

Ultrasonic tests can, under certain conditions, be applied for detecting in insulating materials used for transformers faults which cannot be ascertained by conventional voltage tests. For example, they can be used for testing materials which may have occlusions or manufacturing faults (voids) containing an insulating medium with a dielectric constant which differs from that of the other insulating media.

Because of the field distribution in such insulating materials the layer having the lowest dielectric constant will bear the greatest stress. Consequently, field concentrations will occur which will give rise to intense local heating and to leakage discharges. Insofar as the parts surrounding the affected area are immune to the chemical and thermal effects of the discharges, no early damage need be expected at this point. Thus, for example, small air occlusions in ceramic insulators are of little importance, provided that no additional mechanical stresses occur at the same time. Nevertheless, the use of ultrasonic methods has found wide application in the testing of ceramic insulators, which, together with laminated materials in the form of hard paper, are the only insulating materials of interest, used in the manufacture of transformers, which can be tested in this way.

These laminated materials are in the form of rods or strips, in which case they are subjected to a longitudinal stress, or in the form of mouldings or tubes, in which case they are subjected to a transverse stress. Insulating materials with longitudinal stresses are more easily capable of a purely optical inspection, as their sections, which usually are not far apart, provide a clear picture of the structure of the material. Materials with transverse stresses, however, have small sections relative to their large surface, so that a fault may quite easily remain undetected for a long time until extensive destruction of the insulating material has taken place.

The requirements placed on laminated papers are mechanical and dielectric strength, and homogeneity, taking into special consideration the prevention of air occlusions. Random tests of dielectric strength will provide only in isolated instances information on laminating defects, because the other parts are in a position to withstand the voltage test, which is applied for only a very short time. It therefore seemed advisable to attempt to determine the acoustic homogeneity of insulating materials by means of ultrasonics and to deduce therefrom the electrical homogeneity. Tests carried out with various samples of non-impregnated pieces of insulating material showed, however, that the material had no sound permeability whatsoever, i.e., it was sound-absorbent to such an extent as to prevent the ultrasonic waves from penetrating from more than 5 to 6 mm. The

position is, however, different with laminated papers already in use for some time and therefore largely impregnated with oil. Defects occurring in such materials may remain undetected for a long time, because only small quantities of gas form in the faulty layer, and any gas which may be generated cannot easily escape into the surrounding insulating oil. Damage to individual layers then occurs first, but may spread and affect large areas. Damage occurs only gradually when the leakage discharges become increasingly stronger, resulting in a complete perforation of the insulation. If a strong current now flows through the discharge channels, the stress in the faulty layer is increased to such an extent that it has the tendency to break off, at least partially, if the superimposed winding does not force it to remain in its existing position.

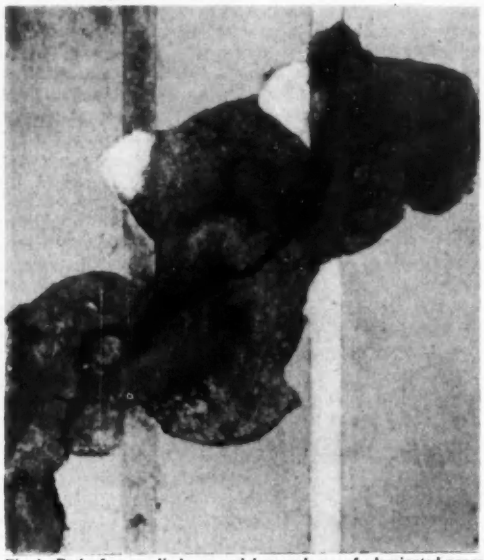


Fig. 1. Path of an arc discharge and damaged area of a laminated-paper tube with a faulty top layer (one-quarter natural size).

Fig. 1 shows a section of an insulating tube with a zonal separation of the faulty layer. It seemed advisable to subject the remaining material to an ultrasonic test, and it was found that the permeability of the material to sound waves, and thus its density, were strongest close to the path of the arc discharges, whilst the undamaged areas were sound-proof. Ultrasonic measurements were repeated in an area where approximately 0·8 mm of the top layer was artificially removed. A clearly detectable echo was immediately obtained, the intensity measured being about the same as that measured close to the actual path of the arc. This necessarily led to the deduction that the top layer of material showed occlusions causing the damage. The section near the damaged area gives important information concerning the quality of the laminated paper.

The saturation of the material with insulating oil varies considerably in the individual layers of the insulation. As laminated-paper tubes are completely sealed (especially at the cut edges) by the application of insulating varnishes, an air occlusion may remain in a faulty adjacent layer which obviously cannot be eliminated even by vacuum treatment.

In addition, it was considered of interest to carry out

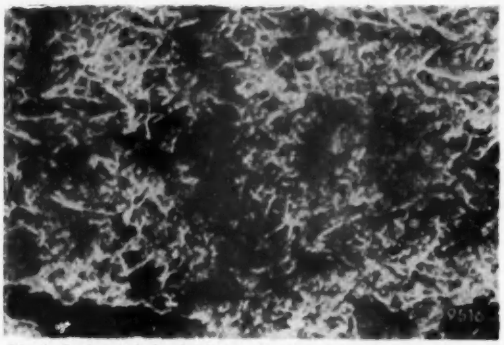


Fig. 2. Inadequately bonded intermediate layer, showing areas of complete adhesion (white tufts) and discharge paths (darker areas). (×10)

tests on the sound permeability of this material after extraction of the residual oil. The results showed that, whereas, in the areas where the faulty layer had been removed, the velocity of sound through the laminated paper was 1284 metres per second at 20°C before removal of the oil, the velocity was 1080 m/sec after extraction of the oil with ether and hexane.

From these tests it was concluded that the laminated-paper tube under investigation had a series of sound-absorbent layers which originated from the fact that the paper was not entirely impregnated with varnish and contained air occlusions. The particularly sound-absorbent top layer of approximately 0·8 mm thickness had, at one dividing line at least, insufficient bonding between the two layers of paper. The synthetic resin used had already partly set when the second layer of paper had been applied, so that the latter layer adhered only locally. In the marginal areas of the tube, however, satisfactory surface bonding had occurred, so that the enclosed air could no longer escape during vacuum treatment. In service, glow discharges took place in the trapped air, finally developing into progressively increasing leakage discharges. Such an intermediate layer is illustrated in Fig. 2, which shows that the discharges do not pass through those areas where there is complete adhesion (shown in the illustration as white tufts, which represent the individual paper fibres lifted up when the adherent areas were pulled apart). The darker areas in Fig. 2 represent the discharge passages, which progress either between the two adhering areas or along one of them.

If the faulty layer is near the surface of the laminated-paper tube, blisters are likely to form during vacuum treatment of the transformer, and this defect may therefore remain undiscovered. Consequently, it seems advisable to treat laminated-paper tubes in a vacuum chamber, prior to their use, to bring out any blisters which may form. Ultrasonic measurements on dry materials cause considerable difficulties, because they are usually completely sound-absorbent, as already mentioned. It is therefore open to consideration whether laminated-paper tubes should not be vacuum-impregnated with oil, prior to their mounting in transformers, and ultrasonically tested. It may also be advisable not to coat these tubes with insulating varnish, so as not to reduce unnecessarily the absorption capacity of the laminated-paper surface, especially at its cut areas.

ERRATUM

In the article on "Ferritic-Austenitic Weld Joints in Thermal Power Stations" in our issue of March 1958, the seventh line of Column I should read:—"... carbon will migrate from the non-stabilized to the stabilized section of the ferritic part ...".

Cutting Tools with Helical Carbide Teeth

By N. A. Rozno. (From *Stanki i Instrument*, No. 11, 1957, pp. 29–32, 8 illustrations.)

Applications of carbide-tipped tools with cutting edges of a helical shape have hitherto been rather limited. The special feature of carbide tools with helical teeth is the exceptionally large helix angle of the teeth, ranging from 20 to 50 deg. for the machining of the more common materials to as much as 70 deg. for the harder steels.

The hand of rotation of the helix is of importance. Generally, multi-edge carbide tools, and particularly milling cutters with straight teeth, are made with a left-hand helix for left-hand rotation of the tool. However, a study of these tools in operation, during the machining of profiles and slots, has shown that the chip tends to move towards the face of the tool, thereby clogging up the interstices between the teeth and causing stoppages. Consequently, although it is advisable in certain cases to use a left-hand helix for left-hand rotation of the tool (e.g., with end-milling cutters when the end of the cutter is brought into contact with the work for milling slots), helical carbide tools are usually made with a right-hand helix for left-hand rotation of the tool.

With large helix angles, a sharp angle is formed at the tool face, weakening the edge. To increase strength over a short length of the tool axis, the edge is provided with a rake angle of ±3–5 deg., the negative rake being recommended for large cutters and severe cutting conditions, and the positive rake for light cuts.

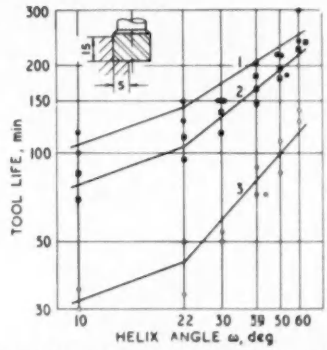


Fig. 1. **Effect of helix angle on tool life, when end-milling 0·45% carbon steel of different hardness values.**

A study of milling cutters with helical carbide teeth of different helix angles has demonstrated the substantial effect which this factor exercises on tool life. The results of these investigations are shown in Fig. 1, which refers to tests carried out on the machining of 0·45% carbon steel of different Rockwell hardness, i.e., 19–22 (curve 1), 28–31 (curve 2), and 45–48 (curve 3). In these tests, the tool was an end mill of 50 mm diameter with helical carbide teeth having a front rake angle of —5 deg. and a side angle of +16 deg., the cutting speed being 150 m/min and the feed per tooth 0·1 mm. It can be seen from Fig. 1 that there is a slight increase in life to be derived from increasing the helix angle ω from 10 to 22 deg., the effect being most pronounced between 22 and 60 deg. Altogether, between 10 and 60 deg., tool life is increased by a factor of from 3 to 4, the greatest increase in tool life being obtained when machining the hardest steel. In this connection, an investigation into the effect of the helix angle on the life of end-milling cutters in the range of cutting speeds between 75 and 240 m/min has shown that an increase in the helix angle ω from 10 to 60 deg. increases tool life considerably through the entire speed range, this increase being most noticeable with helix angles between about 20 and 60 deg.

Until recently, multi-edge tools with straight carbide teeth were not used for machining steel, the reason being that the strength of straight teeth is inadequate, and breakage of the cutting edges is too frequent. Cutters with helical teeth, on the other hand, are subject to normal wear only, without the danger of breakage, even with positive rake angles. This feature is of particular importance in many machining operations with end-milling cutters, when the rigidity of the milling machine is low and cutting speeds are moderate. An investigation of end mills with helical teeth having different rake angles ranging from +10 to —15 deg. has not shown any evidence of substantially greater tool life, the amount being from 30 to 50%. However, as already indicated in Fig. 1, an increase of the helix angle from about 20 to 60 deg. has a marked effect on tool life, and this is true, irrespective of rake angle.

Tests have established that, when the feed per tooth of an end-milling cutter with helical teeth is increased to 0·2 mm, the relation between tool life and helix angle does not change materially from that shown in Fig. 1. Consequently, it is possible to increase the output of milling operations with helical carbide teeth by the simple expedient of increasing the feed per tooth. Similarly, the increase in tool life obtained by using helix angles of 20 deg. or more, in conjunction with a higher feed per tooth, makes it possible to reduce the number of cutting edges of the tool without loss of output.

In the development of cutters with helical carbide teeth, two types of construction have been used, one involving the use of carbide strips of helicoidal shape, and the other a crown with a large number of helical cutting teeth, the latter form of construction being used for tools with a diameter of less than 25 mm, which

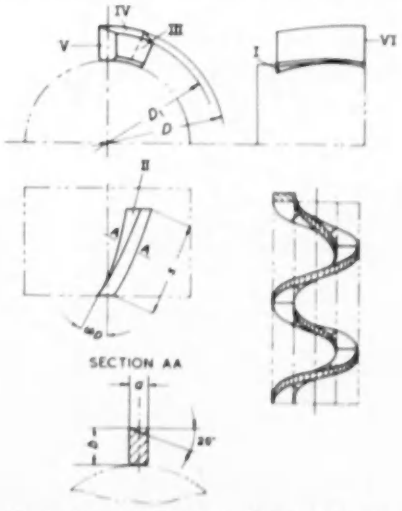


Fig. 2. **Geometry of basic type of helical carbide strip.**

cannot be designed with helical strips when the number of teeth is comparatively high.

For the helical-strip type of construction, the following conditions must be observed :—

(1) The helical surfaces of the strip must have a certain pitch which ensures uniform geometry throughout the length of the tooth.

(2) The cutting edge of the strip must be capable of location on a cylindrical surface of given diameter, or on some other prescribed surface, e.g., conical spherical, etc.

(3) The design of the strip must be such that it can readily be produced in practice, and that any deformation during manufacture must not only be a minimum but must also remain within reasonable limits.

The design of a helical strip of the basic type is shown in Fig. 2, in which the different surfaces are designated I to VI. This design is distinguished by the fact that the generating lines of its helicoidal surfaces II and III are symmetrical and are parallel to the radius of the cylinder on which the strip is located. This condition applies to the cross-section perpendicular to the helical cutting edges. The cross-sectional area and shape of the strip remain constant throughout its length, thus preserving the uniformity of the front and back rakes and the pitch of the helix.

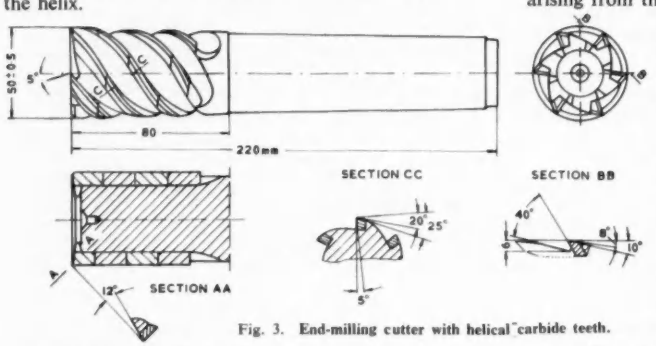


Fig. 3. End-milling cutter with helical carbide teeth.

In addition to helical strips of the basic type shown in Fig. 2, with symmetrically disposed generators of the helical surfaces, all parallel to each other, strips can also be made for face-milling, conical, and form cutters. Furthermore, they can be of various lengths, and with right-hand or left-hand helices. The design of the strip is such that it is possible to construct different sizes of multi-tooth tools with cutting edges of any length and any pitch angle, and to achieve the maximum economy in the use of carbide material with minimum time required for regrinds.

A study of the fit between the helical surface of the carbide strip and the corresponding surfaces of the tool shank has established that the use of one particular strip on shanks of different diameters is practicable, within certain limits determined by permissible inaccuracies in fit. A helical strip of a given diameter can be used within a range of shank diameters, provided that the conditions of constancy and equality of the pitch of the helical groove in the shank and of the strip itself are maintained. These conditions lead to the following equation for determining the helix angle ω_{D_1} of the groove of a shank of a given diameter D_1 :—

$$\cot \omega_{D_1} = \cot \omega_D (D/D_1) \quad .. \quad .. \quad (1)$$

where D is the original outside diameter of the helical strip with a helix angle ω_D. The dimensions of the helical strip are so chosen that each size can be used over a range of different tool diameters, as shown in Table I, in which the notation for b, a, and s are shown in Fig. 2.

TABLE I

Shank Diameter D_1 [mm]	Diameter of Helical Strip [mm] External	Internal	Helix Angle ω_D of Strip [deg.]	b [mm]	a [mm]	s [mm]
10 ±1	10	4	15–30	3	1·5	12
15 ±5	15	8	20–45	4	2	15
20 ±5	20	8	20–45	6	2·5	20
30 ±10	30	14	20–60	8	4	28
50 ±10	50	32	20–60	9	4·5	28
75 ±15	75	55	20–60	10	5	32
100 ±20	100	80	20–60	10	5	34
150 ±30	150	120	20–60	10	5	34

The sizes of helical strip already developed make it possible to construct cutters of between 10 and 250 mm in diameter, though these by no means represent the limits either way. It should also be pointed out that, owing to the favourable conditions for chip removal arising from the design of these helical carbide cutters, they can be constructed with a much greater number of teeth than cutters with straight teeth. An example of a typical end-milling cutter with helical carbide teeth is shown in Fig. 3. For the machining of formed surfaces, radiused slots, or conical slots, appropriately shaped cutters can be used, and these can be made in different sizes, with different pitches and numbers of teeth. Helical cutters of large size are usually of built-up construction, with interchangeable inserts tipped with helical carbide strips. For machining non-ferrous metals and light alloys, tools provided with helical carbide strips, using a large front rake angle, are used.

In the course of the last few years, face-milling and end-milling cutters with diameters between 60 and 120 mm have been developed for the purpose of machining steel and cast iron, an example of a typical face-milling cutter with helical carbide teeth being shown in Fig. 4. Contrasted with existing straight-tooth end mills, these

(*Concluded on page 170*)

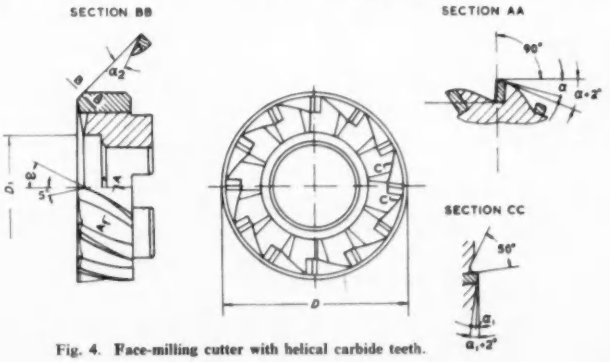


Fig. 4. Face-milling cutter with helical carbide teeth.

The Atomization of Liquids by Flat Impingement Nozzles

By Y. Tanasawa, S. Sasaki, and N. Nagai. (From *The Technology Reports of the Tōhoku University*, Vol. 22, No. 1, 1957, pp. 73–95, 31 illustrations.)

Since the impingement type of nozzle has the feature of being capable of giving a suitable form of spray, it can be widely used in both reciprocating engines and in gas turbines. As a continuation of previous studies,[1] this paper is concerned with measurement of the basic characteristics of flat or 180-deg. impingement nozzles as a standard of comparison for various types of impingement nozzles.

For the purpose of this investigation, the experimental equipment used consisted of a reservoir, from which liquid was forced by compressed air or nitrogen through two opposed fine nozzles, which were mounted in such a way that the jets of liquid produced impinged on each other at the mid-position, forming a flat spray, the shape of which was photographed under spark illumination.

Liquids of different density γ, surface tension σ, and viscosity μ were atomized, and the diameters of the droplets determined either by microscopic measurements of samples collected in a suitable liquid medium or by impressions on tinted papers of uniform thickness.

The flow rate q with different injection pressures p was measured for nozzles with various internal diameters D_1, ranging from 0·43 to 0·95 mm, and the discharge coefficients C determined. These coefficients were rather low, ranging from about 0·53 for the smaller nozzles used to about 0·60 for the larger nozzles, the reason being attributable to the pressure drop occasioned by the use of excessively long tubing of very small diameter between the pressure gauge and the nozzle outlet.

Mechanism of Atomization

The typical modes of atomization of a liquid of low viscosity, e.g., water, are summarized in Fig. 1, in which Fig. 1a shows radial disintegration, the liquid at low impingement velocities spreading into a smooth transparent film and scattering at the free edges of the film in a raindrop pattern. With an increase in impingement velocity, radial disintegration with turbulence occurs, a rough, wavy surface being produced at the centre of the film, but diminishing as it approaches the edge, with the formation of drops as shown in Fig. 1b. With still higher impingement velocities, circumferential disintegration with turbulence occurs, concentric waves are produced near the edge, as shown in Fig. 1c, scattering in the form of rings, which finally break up into a number of drops.

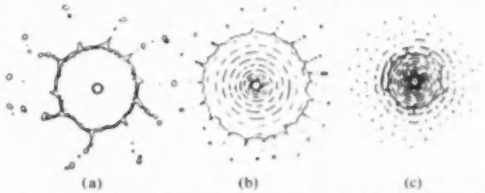


Fig. 1. Typical modes of atomization of a liquid of low viscosity, showing (a) radial disintegration, (b) radial disintegration with turbulence, and (c) circumferential disintegration with turbulence.

These modes are illustrated by the high-speed photographs of films of water in Fig. 2, in which Fig. 2a shows radial disintegration, corresponding to Fig. 1a, at an impingement velocity V of 1·98 m/sec, Fig. 2b shows radial disintegration with turbulence, as in Fig. 1b, at a velocity V of 5·20 m/sec, and Fig. 2c shows circumferential disintegration with turbulence, as in Fig. 1c, at a velocity V of 29·1 m/sec. In all these examples, the internal diameter D_1 of the nozzle is 0·95 mm, the external diameter D_2 is 1·35 mm, and the stability number $Sb = 5{\cdot}38 \times 10^{-3}$. The Reynolds number Re varied between 1330 and 19,500, and the jet number Je between 0·06 and 13·0.

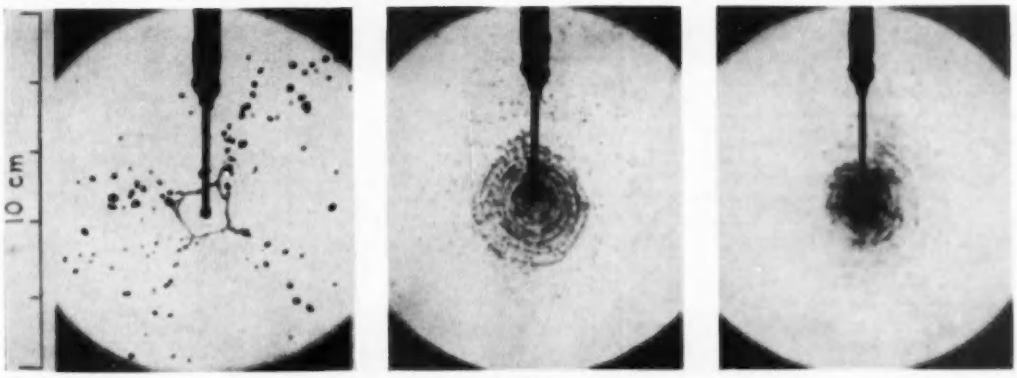
The Reynolds number Re, the jet number Je, and the stability number Sb can be written as

$$Re = \gamma V D_1/\mu g$$

$$Je = \gamma_a V^2 D_1/\sigma g$$

$$Sb = \mu\sqrt{g/\gamma\sigma D_1}$$

where γ is the density of the liquid [kg/m³], μ is the viscosity of the liquid [kg sec/m²], σ is surface tension [kg/m], γ_a is the density of the ambient air [kg/m³], g is acceleration due to gravity [m/sec²], V is the impingement



(a) q = 2·81 cm³/sec, V = 1·98 m/sec, Re = 1330, Je = 0·06

(b) q = 7·33 cm³/sec, V = 5·20 m/sec, Re = 4310, Je = 0·42

(c) q = 41·2 cm³/sec, V = 29·1 m/sec, Re = 19,500, Je = 13·0

Fig. 2. Effect of impingement velocity V on the mode of atomization of water.

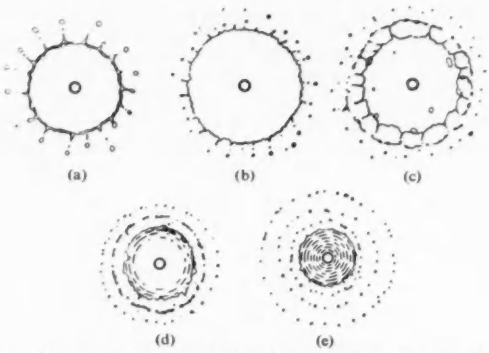


Fig. 3. Typical modes of atomization of a viscous liquid, showing (a) partial radial disintegration, (b) fully developed radial disintegration, (c) radial-circumferential disintegration, (d) circumferential disintegration, and (e) circumferential disintegration with turbulence.

velocity [m/sec], and D_1 is the internal diameter of the nozzle [m].

In the case of viscous liquids, e.g., lubricating oil, the shape of the liquid films is apparently quite different from that of liquids of low viscosity, though the mechanism of atomization is quite similar. The modes of atomization of a viscous liquid are summarized in Fig. 3, in which Fig. 3a shows radial disintegration in a partly developed state, with the production of a smooth and transparent liquid film with dripping at the edges, while Fig. 3b shows radial disintegration in its fully developed state.

In Fig. 3c, radial-circumferential disintegration occurs, in which the droplets are formed both from the radial and circumferential ligaments generated near the free edge of the film. These transient states can be seen clearly with viscous liquids, as they are comparatively more stable than liquids of low viscosity.

In Fig. 3d, circumferential disintegration occurs ; here, concentric circular waves are produced from the outer edges of the film, and drops are formed from the liquid rings detached from the film. The centre part of the film, however, still remains smooth.

When the impingement velocity V exceeds a certain value, and the relative velocity between the film and the surrounding air becomes high, circumferential disintegration with turbulence arises, as shown in Fig. 3e, the liquid film becoming rough and opaque, with the formation of fine drops caused by disintegration of the liquid rings.

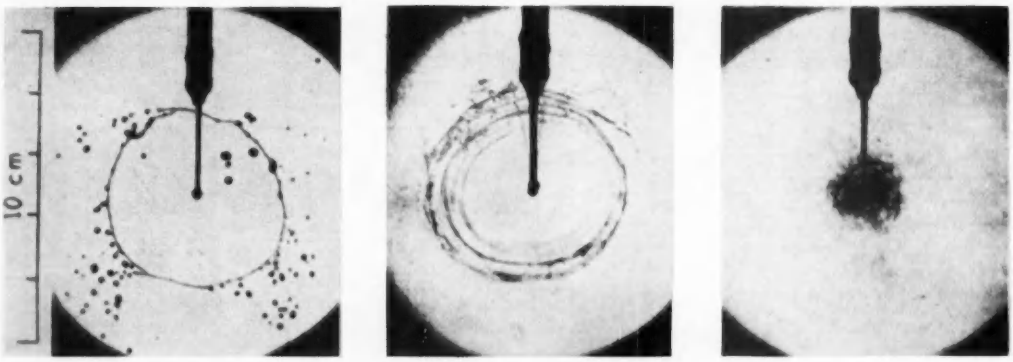
High-speed photographs of the disintegration of films of kerosene (density $\gamma = 844$ kg/m^3, surface tension $\sigma = 29{\cdot}8 \times 10^{-4}$ kg/m, viscosity $\mu = 637 \times 10^{-6}$ kg sec/m^2) with different impingement velocities V are illustrated in Fig. 4, in which Fig. 4a shows radial disintegration, as in Fig. 3a, Fig. 4b shows circumferential disintegration, as in Fig. 3d, and Fig. 4c shows circumferential disintegration with turbulence, as in Fig. 3e. In all the examples shown in Fig. 4, the stability number Sb was $14{\cdot}6 \times 10^{-3}$, and the nozzle had an internal diameter D_1 of 0·74 mm and an external diameter D_2 of 1·00 mm.

The concentric circular ripples produced at the centre of liquid films, as shown in Figs. 1b and 1c and in Fig. 3e, are obviously caused by turbulence in the nozzles, since the Reynolds numbers concerned exceed the critical values of 1500 to 2500 for transitions from laminar to turbulent flow. The dripping type of disintegration of the liquid film at the free edge, shown in Figs. 1a and 1b, and in Figs. 3a and 3b, is due to the radial instability of the film. A free edge is formed when equilibrium exists between the surface tension and the inertia force, and disintegration occurs as a result of disturbance at the nozzle outlet.

The circular liquid film can be considered as a type of two-dimensional liquid column, as shown in Fig. 5, which illustrates the cross-sectional form of (a) a dilational wave and (b) a sinuous wave produced by radial and circumferential disintegration. Thus, the theory of instability of jets of liquid issuing from a circular orifice may be applied in the present case.

According to Rayleigh[2] and some other investigators, the infinite disturbance produced by a sudden outward flow of liquid from the orifice into the surrounding air develops into finite dilational waves, as in Fig. 5a, until the jet of liquid disintegrates by itself. For liquids of low viscosity, this instability occurs when the wavelength λ of disturbance is more than πD, where D is the original diameter of the jet, and attains maximum instability when $\lambda = 4{\cdot}51\,D$.

Similarly, in the case of liquid films, it can be assumed that the amplitude of infinite disturbance produced at the nozzle outlet increases infinitely in the form of dilational waves, when the wavelength of disturbance λ is several



(a) $q = 3{\cdot}46$ cm^3/sec, $V = 4{\cdot}07$ m/sec, $Re = 407$, $Je = 0{\cdot}43$

(b) $q = 10{\cdot}0$ cm^3/sec, $V = 11{\cdot}8$ m/sec, $Re = 1200$, $Je = 3{\cdot}59$

(c) $q = 25{\cdot}5$ cm^3/sec, $V = 30{\cdot}0$ m/sec, $Re = 3000$, $Je = 23{\cdot}2$

Fig. 4. Effect of impingement velocity V on the mode of atomization of kerosene.

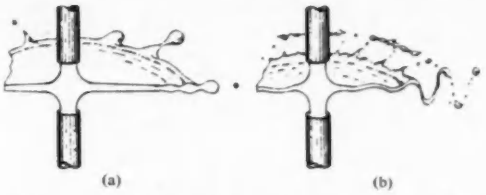


Fig. 5. **Cross-sectional form of waves produced with radial and circumferential disintegration, showing (a) a dilational wave, and (b) a sinuous wave.**

times greater than the film thickness T, reaching a maximum value for a higher value of λ. At this point, the thickness of the free edge increases, owing to the increased amplitude, and the diameter of the scattered drops is several times the original thickness of the film. To satisfy the condition of continuity, the film with its thickened edge cannot separate as a whole in the form of a ring, but separates radially with a certain circular pitch, i.e., as a raindrop pattern, if it is assumed that the radial flow velocities in the film and in the scattered drops are nearly equal.

Disintegration in the form of a ring, as shown in Fig. 1c and in Figs. 3d and 3e, is caused by the circumferential instability of the circular liquid film with regard to air resistance. The amplitude of infinite disturbance acting on the film is increased in a sinuous form (Fig. 5b) by the relative velocity v of the surrounding air of density γ_a.

The criterion as to whether the amplitude of infinite disturbance increases or not is determined by the wavelength of the disturbance. Calculations of critical wavelength λ_c have been made by York and Stubbs[3], and by Hagerty and Shea[4], for liquid films of low viscosity and uniform thickness, and can be applied as an approximation in this case. Their results show that $\lambda_c = 2\pi\sigma g/\gamma_a V^2$, and that maximum instability occurs at nearly $2\lambda_c$.

Insofar as the stability of the liquid films is concerned, the most stable films are obtained with liquids having a high surface tension, a high viscosity, and a low density[5]. The combined effect of these properties is summarized in the stability number *Sb* already referred to.

Diameters of Liquid Films

Measurements were made of the diameters D_3 of the circular films of water produced with different impingement velocities V through various nozzles with internal diameters D_1 ranging from 0·43 to 0·95 mm. With films of water, the diameters of the films produced attained a peak value with impingement velocities V of about 5 to 6 m/sec, ranging between about 14 mm for the 0·43-mm nozzle to about 36 mm for the 0·95-mm nozzle ; with an impingement velocity of 30 m/sec, these values were reduced to about 7 mm and 18 mm respectively.

Since the time required to disintegrate the liquid film is nearly constant and the thickness T of the film is approximately proportional to the nozzle diameter D_1, the diameter D_3 of the film increases with D_1 and V in the range of the dripping type of disintegration, but decreases when the ring type of disintegration commences.

Mean Diameters of Drops

The mean diameter d of drops of water has been determined for various impingement velocities V with nozzles of different internal diameters D_1. The effect of impingement velocity on mean diameter d in the case of drops of water, using a nozzle with an internal diameter D_1 of 0·95 mm and an external diameter D_2 of 1·35 mm, is shown in Fig. 6. The results obtained with a nozzle of 0·43 mm internal diameter and 0·60 mm external diameter are shown in Fig. 7. It may be said that mean diameter d and maximum diameter d_{max} are proportional to $D_1^{0.75}$ and inversely proportional to $V^{0.5}$.

To ascertain the effect of surface tension σ on mean diameter d, ethyl alcohol was added to the water, so as to keep the viscosity of the solution within reasonable limits. The results obtained with an impingement velocity V of about 30 m/sec, using a nozzle of 0·62 mm internal diameter and 0·80 mm external diameter, are shown in Fig. 8. It was found that there was a tendency for the

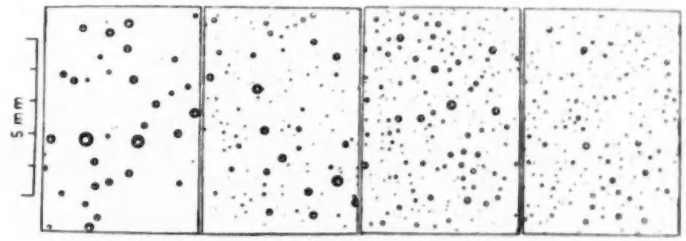


Fig. 6. **Effect of impingement velocity V on the mean diameter d of drops of water, using a nozzle of 0·95 mm internal diameter.**

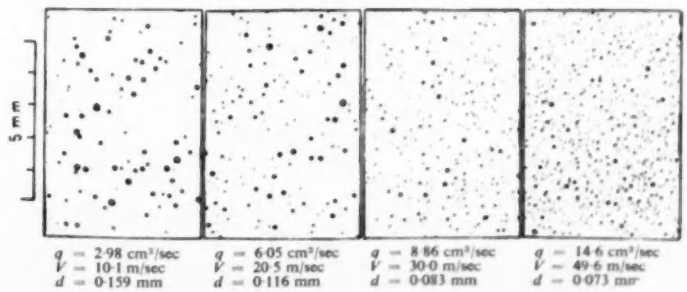
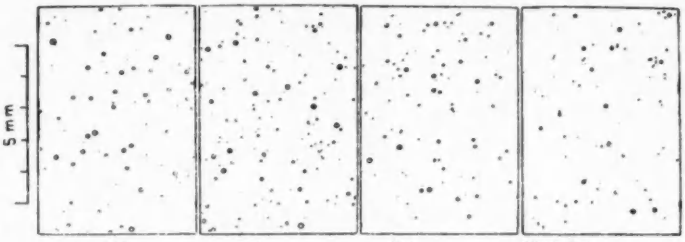
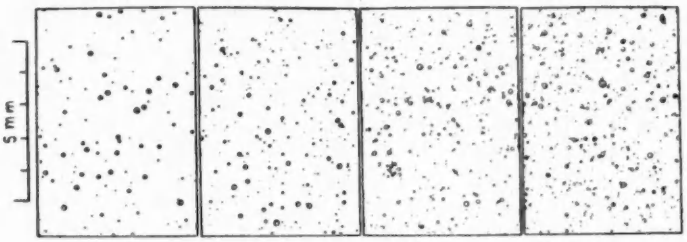


Fig. 7. **Effect of impingement velocity V on the mean diameter d of drops of water, using a nozzle of 0·43 mm internal diameter.**



γ	1000	990	976	934 kg/m³
σ	$74{\cdot}6 \times 10^{-4}$	$52{\cdot}3 \times 10^{-4}$	$38{\cdot}0 \times 10^{-4}$	$28{\cdot}8 \times 10^{-4}$ kg/m
μ	122×10^{-6}	144×10^{-6}	216×10^{-6}	264×10^{-6} kg sec/m²
$\sigma g/\gamma$	$73{\cdot}1 \times 10^{-6}$	$51{\cdot}8 \times 10^{-6}$	$38{\cdot}2 \times 10^{-6}$	$30{\cdot}2 \times 10^{-6}$ m²/sec³
d	0·117	0·112	0·105	0·098 mm

Fig. 8. **Effect of surface tension σ on the mean diameter d of drops of mixtures of ethyl alcohol and water, using a nozzle of 0·62 mm internal diameter and an impingement velocity V of about 30 m/sec.**



γ	1000	1098	1131	1187 kg/m³
σ	$74{\cdot}6 \times 10^{-4}$	$66{\cdot}3 \times 10^{-4}$	$64{\cdot}0 \times 10^{-4}$	$63{\cdot}7 \times 10^{-4}$ kg/m
μ	122×10^{-6}	405×10^{-6}	738×10^{-6}	3190×10^{-6} kg sec/m²
d	0·117	0·112	0·105	0·100 mm

Fig. 9. **Effect of viscosity μ on the mean diameter d of drops of solutions of glycerine in water, using a nozzle of 0·62 mm internal diameter and an impingement velocity V of about 30 m/sec.**

value of d to decrease slightly with decreasing kinematic surface tension ($\sigma g/\gamma$), and it is concluded that the effect of surface tension on mean diameter is proportional to $(\sigma g/\gamma)^{0{\cdot}25}$.

With regard to the effect of viscosity μ on mean diameter d, extensive measurements were made with water, glycerine, and lubricating oils, but no variations in the value of d were observed for impingement velocities V higher than 10 m/sec. The results obtained with a solution of glycerine for an impingement velocity of 30 m/sec, using a nozzle of 0·62 mm internal diameter and 0·80 mm external diameter, are shown in Fig. 9.

The fact that viscosity appears to have no effect on mean diameter d is a remarkable feature of the impingement nozzle, when compared with other nozzles, in which the value of d generally decreases with viscosity. The reason is that any increase in mean diameter caused by viscosity is cancelled out by the decrease in the thickness of the film at the free edge as viscosity increases.

Another feature of this type of nozzle is that the ratio of maximum droplet diameter d_{max} to mean diameter d is 1·62 — a very small value compared with other nozzles, in which d_{max}/d is between 2·0 and 2·5.

Penetrability of Sprays

The relation between the impingement velocity V and the initial velocity v_0 of drops leaving the liquid film can be determined by measuring the maximum height h

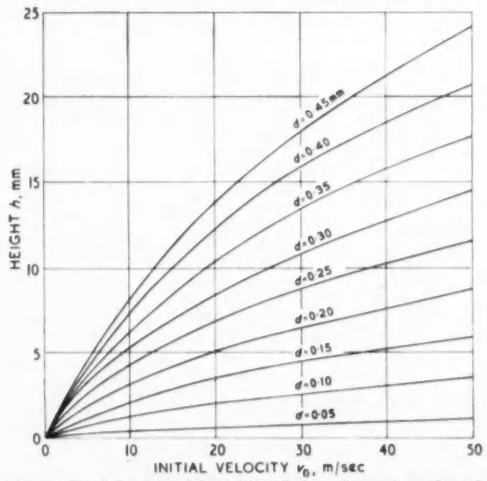


Fig. 10. **Graph for determining initial velocity v_0 from values of maximum attainable height h and droplet diameters d obtained experimentally.**

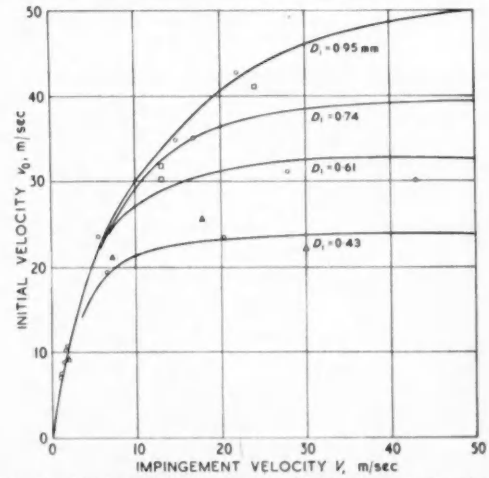


Fig. 11. **Initial velocity v_0 as a function of impingement velocity V for nozzles of different internal diameters D_1.**

attainable by a drop of diameter d thrown vertically upwards with an initial velocity v_0. In Fig. 10 this height h is shown graphically as a function of initial velocity v_0 for various diameters d, taking into account variations in the drag coefficients of the drops with Reynolds number. From Fig. 10, initial velocity v_0 can be obtained, if the values of h and d have been obtained experimentally. The relation between impingement velocity V and initial velocity v_0 for water, using nozzles of different internal diameters D_1, is shown in Fig. 11. It will be noted that, in the case of smaller values of V, initial velocity v_0 increases rapidly and independently of D_1. For larger values of V, however, v_0 has a tendency to reach a maximum value which is approximately proportional to the corresponding value of D_1.

Application of Results

As it is only reasonable to expect that the flat impingement type of nozzle produces the most favourable atomization, several designs of impingement nozzle have been proposed. One of these (Fig. 12) utilizes a poppet-type target with a conical stem to obtain a flat spray with a variable flow rate. Fig. 13 shows the mode of atomization of this type of nozzle and indicates that the required conditions are satisfactorily fulfilled. It can therefore be used in diesel engines with direct injection.

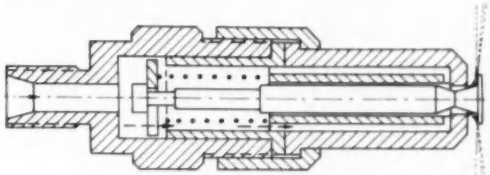


Fig. 12. Poppet type of impingement nozzle.

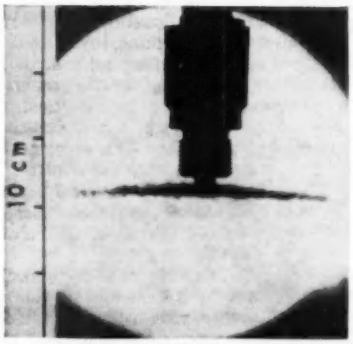


Fig. 13. Mode of atomization of a poppet type of impingement nozzle, shown from the side.

It should be noted that impingement nozzles for use in gas turbines with annular combustion chambers have also been proposed, and experiments in this connection are under way.

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(3) J. L. York and H. E. Stubbs : *Trans. ASME*, Vol. 75, No. 7, 1953, page 1279.

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New Permanent-Magnet Couplings using Sintered Oxide Materials

(Concluded from page 139)

plate which serves the same purpose as the dished plate used for the sleeve-type coupling.

To avoid eddy currents, in both types of couplings it is advisable to have the intermediate plates made of an electrically non-conductive synthetic material. Where this is not possible, owing to high mechanical pressures, the intermediate plates can be made of non-magnetic steels with a high specific resistance. In no cases should aluminium or copper be used, since they enable eddy currents to be generated which convert an appreciable proportion of the energy available into heat. The problem of electrically conductive partitions or intermediate plates requires particular attention for powers above 2 hp. For higher powers, it is necessary to use suitably subdivided plates to avoid eddy currents.

A completely new field of application for these magnetic couplings is their use as misalignment couplings. For ratings up to 1 hp, the face-type couplings are obviously suitable for parallel or angular misalignments, since they are of particularly simple construction and can transmit torques without a positive mechanical connection. The amount of permissible misalignment is limited in practice only by the fact that excessive eccentricities or air gaps reduce the value of their torque capacity. Another advantage is that these couplings can be easily disconnected, which is of importance in the case of inaccessible flange-mounted motors.

Their use as adjustable overload couplings also offers considerable possibilities, as slipping torque can be adjusted by altering the distance between the coupling members. A sudden excessive speed change or stoppage of the driven machine will cause the coupling to fall out of step, in the same way as a synchronous motor. Depending on the relative position of the poles and the speed of the driving member, a rapid succession of positive and negative torques of brief duration will occur, and these will cancel each other out while being transmitted to the coupling member of the driven unit, so that the drive in this condition will be practically completely disconnected. The connection is operative again at standstill or when the two coupling members return to synchronous running conditions. No eddy currents are generated in the magnets during the disconnecting process ; slight eddy currents occur only in the iron of the return circuits, but these can also be eliminated, where necessary, by making the return-path components of soft iron.

In certain applications, sudden load changes or cyclically varying loads may give rise to oscillations of the two coupling members. In such cases the presence of some eddy-current damping is a desirable feature. The slight amount of eddy currents in the iron parts can be increased, if required, by covering the pole surfaces of the coupling members with copper sheets or rings of suitable thickness, rigidly attached to the magnets and rotating with them. When such couplings with vibration-damping properties are used as overload couplings, care should be taken to ensure that they are not run at such low speeds as to cause excessive heating.

The couplings described have torque ratings up to 100 cm kg, but, in principle, there is nothing to prevent the construction of even larger units, in which case the magnets must be made up of several sections.

GERMANY

Heteropolar Synchronous Machine with Unwound Rotor

By G. HAGEDORN. From *AEG Progress*, No. 4, 1957, pp. 169–170, 4 illustrations.)

THE synchronous machine described in this article is a true heteropolar machine, magnetic north and south poles being arranged alternately around the periphery of the rotor. This form of construction has the advantage of considerably better utilization of the active magnetic material, since the inducing alternating flux is more than double that of the homopolar machine for the same air-gap induction. It is therefore desirable to combine the advantages of the heteropolar and homopolar machines, i.e., full utilization of material and the use of an unwound rotor. A further advantage of the arrangement is that no permanent-magnet materials are employed in the rotor since, on account of their brittleness, these usually have inferior mechanical properties.

The principle of the machine is shown in Fig. 1, in which it will be seen that the rotor (a) has no winding and is similar in construction to a dog-clutch. By means of a stationary electromagnet or permanent magnet (b), the rotor poles, which are magnetically insulated from each other, are given alternate polarity. The laminated stator core (c) with the a.c. winding (d) can be arranged at any convenient position around the periphery. Several magnets and stator packets may, however, be fitted, so as to utilize fully the entire periphery.

As a permanent-magnet generator for use with a hydraulic turbine, this type of machine is eminently satisfactory. Applications of a small synchronous machine of this kind are as a bicycle-hub dynamo, dispensing with the conventional friction-wheel drive, as a slow-running synchronous motor, or as a revolution or phase-sequence indicator. In this design, permanent magnet and stator core comprise a single unit, while the rotor consists of two toothed discs of sheet metal, magnetically insulated from one another.

In another design, in this case a generator with a rating of 1 kW at 3750 rpm, 312 cps, excitation is also by means of a permanent magnet. The weight of this machine is about the same as that of a d.c. generator, and its efficiency is about 73%, though this value can be still further increased. The external characteristic is slightly drooping, and the voltage drop without a capacitor amounts to about 15% between no-load and full load. Compensation by means of a series capacitor of the armature reaction and the leakage reactance drop yields a considerably higher output. The rotor is simpler and more reliable than a cage-wound rotor. The ring coils serve either to re-energize the permanent magnets of the machine, when necessary, or as an excitation winding when soft-iron magnets are used. In this case, the bearing end-shield can also be designed to carry flux, as shown in Fig. 2.

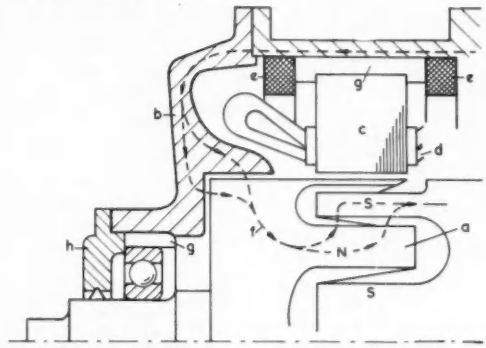

Fig. 2. **Bearing end-shield of a stator-excited heteropolar machine.**
(a) Dog-clutch rotor.
(b) End-shield carrying magnetic flux.
(c) Stator core.
(d) A.C. winding.
(e) Excitation coils.
(f) Path of flux.
(g) Magnetic insulation.
(h) Non-magnetic bearing cap.

In this type of machine, even when designed for electromagnetic excitation, no brushes and slip-rings are necessary. Consequently, sparking, brush friction, radio interference, and the danger of explosion are eliminated. As distinct from synchronous induction motors, which require a low rotor voltage, but high excitation currents and therefore heavy brushgear, the excitation voltage can be of any desired value. With permanent-magnet excitation there are further advantages; thus, excitation equipment is unnecessary, and the efficiency, particularly in the case of miniature motors, is high.

Formerly, magnetic material could not be incorporated in the rotors of synchronous motors, because demagnetization occurred on induction-starting. In the new form of construction the leakage flux has a stabilizing effect and, owing to the abnormally high specific current loading, prevents the magnets from being demagnetized. Hence, the machine is not only fully capable of withstanding short-circuits as a generator, but can also work as a motor with permanent-magnet excitation. The high leakage flux also has the effect that, after removal and replacement of the rotor, there is only an insignificant reduction in power.

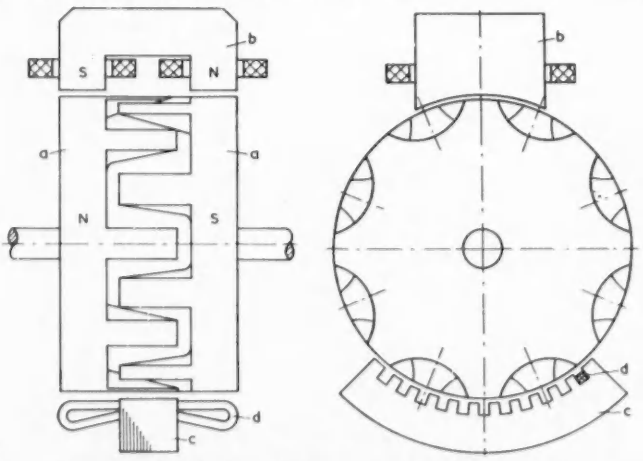

Fig. 1. **Principle of the heteropolar synchronous machine with unwound rotor.**

Fuel-Ash Attack on Aluminium-Coated Stainless Steel

By J. E. Srawley. (From *Corrosion*, Vol. 14, No. 1, January 1958, pp. 54–56, 6 illustrations.)

In recent years the problem of attack by the combination of the gaseous products of combustion and the ash of residual fuel oils on the components of boilers and turbines has become one of the most serious limiting factors in the further development of shipborne power plants. Established materials deteriorate rapidly as temperatures are increased for the purpose of increasing efficiency. Presumably because of the complexity of the situation, no thoroughly satisfactory account of the conditions which may occur in boilers and turbines has yet been published, most attention usually being given to the influence of vanadium compounds present in significant amounts in most residual oils.

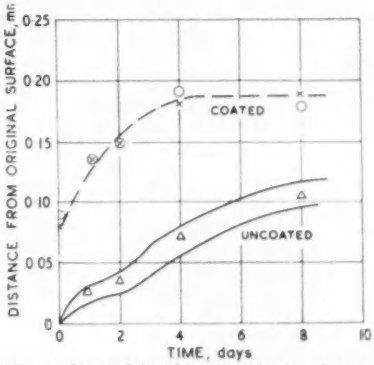

Fig. 1. Advance of the scale/metal interface of uncoated specimens and the coating/parent-metal interface of coated specimens.

As a contribution to the widespread search for materials offering promise of superior behaviour, and bearing in mind the undoubted value of aluminium coating on steel in other applications, an investigation has been carried out at the U.S. Naval Research Laboratory on hot-dipped aluminium coatings applied to Type 310 stainless steel,* which is commonly used for boiler and tube support plates.

Experimental Procedure

Coatings were applied in the laboratory by dipping specimens cut from a single bar of commercial Type 310 stainless steel into a bath of 99·997 grade aluminium at 1400°F. A flux cover was used on the bath to ensure satisfactory coating of the whole surface of each specimen. After dipping, air-cooling, and washing to remove adhering flux, some specimens were heat-treated to diffuse aluminium into the steel. After 24 hr at the testing temperature of 1700°F, diffusion had occurred to such an extent that the effect of prior heat treatment on the coating structure could hardly be distinguished. At this stage the average coating thickness was about 0·005 in.

Testing consisted of heating specimens in an unsealed muffle furnace for periods up to 14 days. No attempt was made to control the atmosphere, which therefore consisted of the ambient air at atmospheric pressure. The specimens were contaminated with a mixture of equal parts of sodium sulphate and vanadium pentoxide, the quantity of the contaminant being small in relation to the size of the specimen. In the least severe case a single initial application of 1 mg/cm² of specimen surface was made, while in the severest case specimens were treated each day with 4 mg/cm². Evaluation of the effect of contamination was carried out by microscopic examination of sections of the specimens normal to their surface. Specimens were usually cooled and weighed daily as an auxiliary means of following the progress of attack.

Results

Under the given experimental conditions the aluminium coatings did not reduce or delay attack on the specimens to any significant extent. Prior heat treatment to diffuse the coatings did not influence the result. In one experiment, comparisons were made between uncoated specimens and coated specimens of two types, the difference between them being in the prior heat treatment given. One heat treatment consisted of heating to 1700°F in air, holding at temperature for 1 hr, and then air-cooling, this being simply a nominal stabilizing treatment. The other heat treatment was a proprietary process aimed at developing a special type of surface layer (a so-called preconditioning treatment).

Specimens were contaminated with 2 mg/cm² of 50% Na_2SO_4 and 50% V_2O_5, heated to 1700°F, held at temperature for 22 hr, and then cooled and weighed. This cycle was repeated for 4 days, specimens being removed after each cycle for micro-examination. After the 4-day period, the remaining specimens were again contaminated and then allowed to remain at temperature for a further 4 days. Thus, these specimens were at temperature for a total of 8 days and were contaminated with a total of 10 mg/cm² of the mixture.

It was found that there was no substantial difference in the behaviour of the two types of coated specimens, but comparison between the coated and uncoated specimens showed an important feature. Although the penetration of scale into the coated specimen was irregular, compared

* 24 to 26% Cr, 19–22% Ni, and up to 0·25% C.

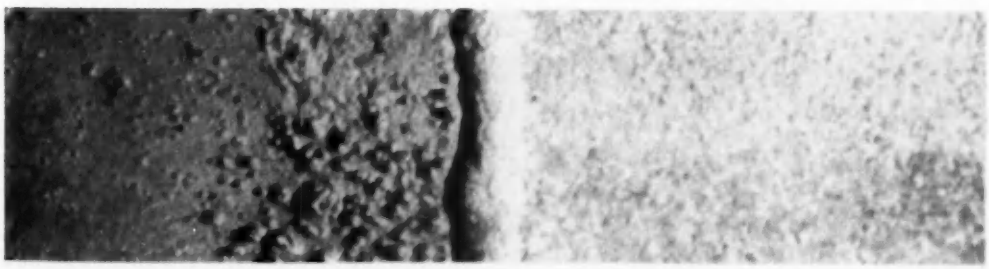

Fig. 2. Appearance of composite plate after exposure, showing (left) the coated section, (centre) the weld, and (right) the uncoated section.

with the uncoated specimen, it had advanced beyond the coating/parent-metal interface in several places. This interface in turn had advanced well beyond the corresponding position of the scale interface of the uncoated specimen. Thus, attack on the uncoated specimens had not reached a depth equal to that of the coatings by the time the coatings had been effectively penetrated. In such circumstances, it cannot be said that the coatings had any protective value.

In Fig. 1 the results of microscopic measurement on all the specimens are plotted. The regularity of the attack on the uncoated specimens is shown in the lower curves, which represent the range of ten measurements per specimen. The upper curve represents the advance of the coating/parent-metal interface for the coated specimens and for both heat treatments within the experimental error, as shown by the plotted points. It is notable that the advance of the scale on the uncoated specimens was always behind the advance of the coating-metal interface. After eight days, when the coating had been penetrated, the scale front on the coated specimens in the penetrated regions was ahead of that on the uncoated specimens. These regions spread rapidly with increased exposure.

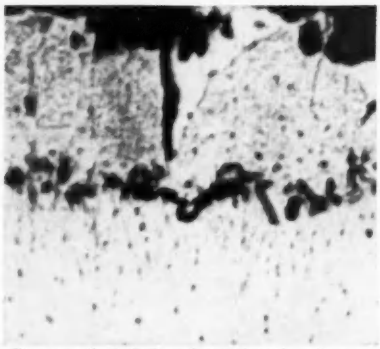

Fig. 3. Structure of relatively undamaged coating after exposure for several days at 1700°F. (× 280, etched)

In other experiments heat treatment of the coating for 5 hr at 1900°F did not show any improvement in behaviour, although the coating was much more effectively diffused by this heat treatment than by those mentioned above. Coatings which were tested without any prior heat treatment behaved as well as those that were heat-treated. This is not surprising, in view of the fact that test (and service) conditions involve long exposure at temperatures where diffusion is quite rapid, so that any heat treatment may be regarded as the equivalent of a preliminary service exposure, where diffusion is concerned.

A check on these results was provided by a test which corresponded closely to one type of service, in which one half of a piece of stainless-steel sheet was dip-coated with aluminium and then joined to the other uncoated half by butt-welding. The composite piece was then exposed in a boiler, the appearance of this composite piece after removal from the boiler being shown in Fig. 2. Quite clearly, the coated material has deteriorated to a greater extent than the uncoated steel. Micro-examination revealed only traces of the original coating between the areas of deepest attack.

The structure of a relatively undamaged coating, such as would be obtained by heating the dipped specimen in air alone for several days at 1700°F or several hours at 1900°F, is shown in Fig. 3. Temperature and duration of heating affect only the thickness of the layers and not the other features of the structure, provided that the structure has formed, and the depletion of aluminium by oxidation at the surface is not great enough to have an effect. There are three characteristic layers, i.e., (1) the outer, two-phase layer, (2) a narrow, intermediate single-phase layer, and (3) an inner two-phase layer which has a sharp boundary with the parent steel. Microhardness measurements indicate that the aluminium content beyond this boundary is low, probably less than 1%. Examination of pseudo-binary alloys of Type 310 composition with aluminium indicates the solubility of aluminium in austenite of this composition to be of the order of 1% or less.

The two phases in the outer and the inner duplex layers are apparently the same, although almost certainly of different composition. As aluminium is depleted by continued oxidation at the surface, the relative amounts of the two phases in the outer layer change, and the intermediate single-phase layer diminishes. At the same time, the inner duplex layer advances into the steel.

Fig. 4, at a lower magnification, shows penetration of the coating in part of one of the 8-day specimens referred to earlier. The residual coating appears at the right-hand side of the illustration, and close examination shows it to be depleted of aluminium, compared with a coating heated in air alone for the same period.

Conclusion

The results of this investigation were unquestionably negative, and it was evident that, under the selected conditions of testing, Type 310 stainless steel was not protected by hot-dip aluminium coating and that prior heat treatment of the coatings exercised no great effect. Confirmation that these results are indicative of what may be expected in service is provided by the example of a boiler service test. Other burner tests and tentative results from shipboard service trials also are consistent with these findings.

In spite of this excellent agreement, it is considered that the test methods used were over-simplified and did not cover adequately the whole range of variables possible in service exposure. In the present investigation, such a procedure was justified by expediency, but there was the safeguard of comparing the results with others obtained by different procedures. For a thorough, extensive investigation of resistance of materials to fuel-ash attack, a carefully designed burner test-rig, in which specimens would be exposed to conditions closely simulating those prevailing in service, must be regarded as a necessity. Furthermore, an adequate programme to correlate the results obtained in such a rig with results of actual service trials would have to be undertaken before the former could be accepted with confidence.

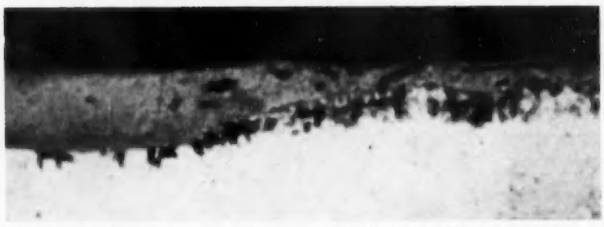

Fig. 4. Penetration of coating after exposure for 8 days at 1700°F. (× 72, etched)

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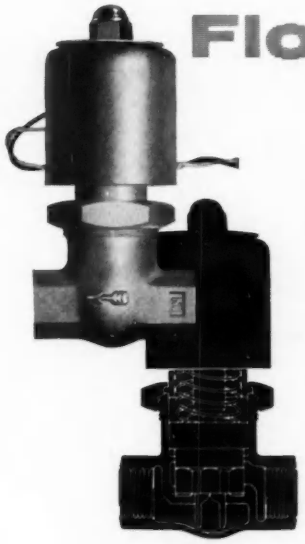

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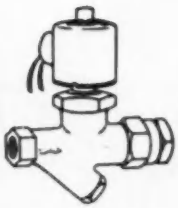

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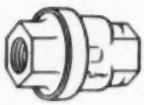

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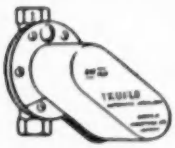

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British Industrial Developments

Monorail Conveyor Finishing Line for Domestic Refrigerators

For some time, Astral Equipment Limited, a subsidiary of Morphy-Richards Limited, have used a passivated zinc-coated sheet in the manufacture of casings, door panels, etc. for their range of domestic refrigerators. As a result, it was decided that, when installing a new finishing shop in their Dundee factory, the only pretreatment required, prior to painting, would be degreasing on the priming conveyor through a trichlorethylene unit.

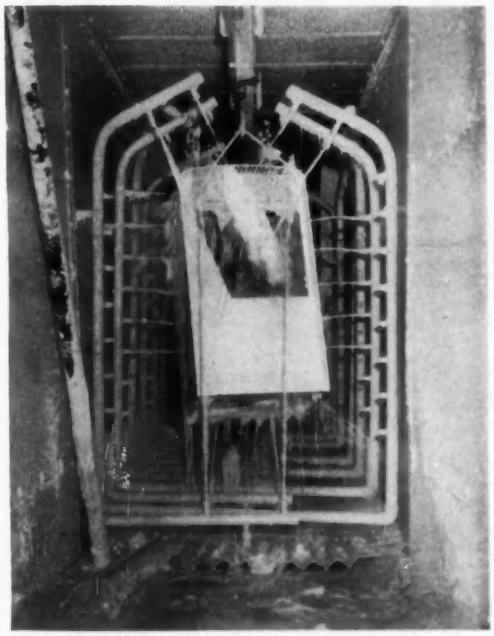

Fig. 1.

In the new finishing line, the prime coat is applied by means of flow coating, and monorail conveyor systems are used in the paint shop, so that cabinets, door panels, etc. requiring finishing can reach a loading area at the end of the production line and can immediately be transferred to the degreasing and prime-coat painting conveyor. This conveyor system has an approximate endless length of 580 ft and is provided with work-carrying hooks with a 4-min pitch throughout the entire length. After degreasing, a length of conveyor has been allowed for tack-ragging, after which the work passes to the flow-coating unit.

The flow-coating unit comprises a vestibule, followed by the flow-coating section proper, and then an enclosed vapour tunnel, to allow flow-out of the paint before stoving. As indicated in Fig. 1, which shows a cabinet entering the flow-coat section, the flow coater consists of a series of annular rings fitted with flow-coating nozzles arranged to cover both the interior and exterior surfaces completely, excess paint draining back to one of two working sumps. Each flow-coating ring is separately valved and, in addition to the two working sumps, a solvent tank is provided, to enable the system to be flushed out, as required. The arrangement of pipework is such that the circulating pump can draw from either of the three sumps, the drains also being interconnected and valved. In addition to the main circulating pump, a subsidiary pump is provided for use during long shut-down periods to keep the paint in good condition.

With a conveyor speed of 7 fpm, the draining time after paint application is approximately 20 min and, during the whole period, the work is in the vapour tunnel to give flow-out. At both the entry and exit ends of the flow-coat tunnel a vapour seal is provided, to prevent the escape of solvent vapour into the surrounding shop area. These seals have been specially designed to avoid draughts in the vapour tunnel itself; otherwise, interference with flow-out would arise.

After leaving the flow-coat vapour tunnel, the work is conveyed through a direct gas-fired air-circulated prime-coat stoving oven, which has been designed to permit, at a conveyor speed of 7 fpm, a travel time of approximately 16 min. The oven is provided with thermostatic control, to enable working temperatures of up to 400°F to be quickly and easily attained. To prevent spillage of hot fume-laden air and also to conserve fuel, air seals are provided at the entry and exit ends of the oven, these seals delivering high-velocity air streams across the working opening.

After emerging from the prime-coat stove, the work then traverses a cooling leg, with sufficient space available to permit any rubbing down which may be necessary. The work is then removed from the jig used for conveying through the degreasing and flow-coating unit and is rehung on a second conveyor system, also of the monorail pattern, having a length of approximately 340 ft and travelling at 6 fpm, the refrigerator bodies being inverted, as shown in Fig. 2, and other parts being rejigged to suit the following electrostatic painting operation. All parts are tack-ragged on the flushing conveyor before reaching the spray booth.

The electrostatic system used for the finish-painting of all parts going to make up the finished refrigerator is of the reciprocating-disc type (Fig. 3), the conveyor being arranged in a loop around the disc and provided with indexing points around the loop. A number of sets of indexing fingers have been provided, all of which are capable of adjustment around the loop, and which are brought into and out of operation pneumatically from a selector station external to the booth. In addition, a spinning cup, for coating that area of the top of the

Fig. 2.

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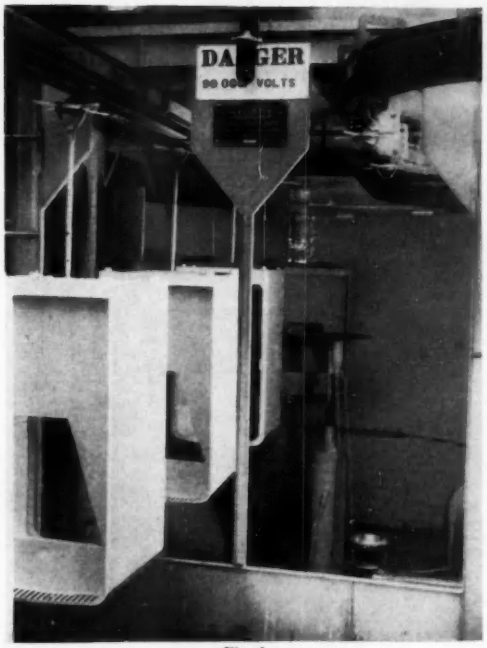


Fig. 3.

cabinet not reached from the reciprocating disc, is provided.

After leaving the electrostatic spray booth, the painted work then traverses an enclosed flash-off tunnel before reaching the finish-coat oven, which, like the prime-coat oven, is of the fully air-recirculated pattern and arranged with direct gas-fired heaters capable of providing working temperatures up to 400°F. The approximate travel time through the finish-coat oven is 19 min at a conveyor speed of 5 fpm. Air seals are provided, as before, and, on leaving the oven, the conveyor passes through the boundary wall of the shop and runs parallel to this wall, parts being removed from the conveyor at this point for inspection and transfer to the final assembly areas.

An important point in the line is that at no time is hand spraying or touching up used, complete coverage both in the case of prime and finishing coats being obtained automatically.

The layout finally adopted was the result of close co-operation between Astral Equipment Limited and Stordy Engineering Limited, who designed, manufactured, and installed the finishing equipment, ovens, etc. The conveyor system is of the Fisher and Ludlow " Flowlink " pattern, the electrostatic equipment being supplied by Henry W. Peabody Ltd., and the trichlorethylene unit by Imperial Chemical Industries Limited.

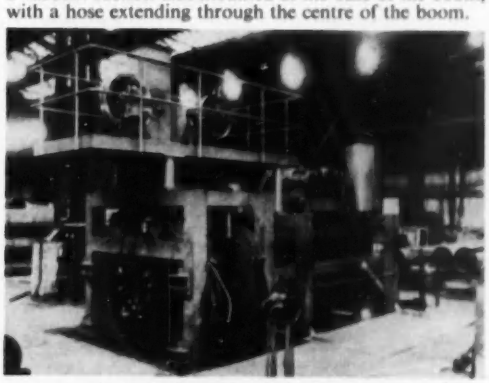
Continuous Edge-Forming and Seam-Welding Machine

It is announced by Quasi-Arc Ltd., of Bilston, Staffs., that equipment recently installed at the Coatbridge works of Stewart and Lloyds Limited for the manufacture of electric fusion-welded pipe comprises a Quasi-Arc/Torrance continuous edge-forming and seam-welding machine for external welding and an internal welding boom for backing up welds. It is stated that, compared with a conventional fusion-welded pipe mill, fewer operators are required and the time taken to change from one pipe size to another is reduced. Furthermore, tacking of pipes before welding is not necessary, while the use of multi-power welding equipment gives welding speeds which are twice those obtainable with single-wire welding.

The Quasi-Arc/Torrance continuous edge former and seam welder forms the edges of the pipe and welds the seams in one operation. It can handle pipe from 18 to 50 in. o.d. in plate thicknesses up to $\frac{3}{4}$ in. The pipe lengths are fed through the machine continuously, butted end to end by a succession of drive rolls which are power-driven at an infinitely variable welding speed by a $7\frac{1}{2}$-hp motor, giving a range of welding speeds between 30 and 96 ipm. As the pipe lengths, which have already been rolled into shape, enter the machine, the edges pass between two edge-forming rolls mounted one above the other. These rolls break the plate edges to produce a circular pipe with good fit-up between the faces of the joint to be welded. Five sets of edge-forming and drive rolls are required for the complete range of pipe sizes.

The machine is fitted with multi-power tandem welding equipment comprising two " Unionmelt" D.S.H. welding heads. The lead head is powered by a continuously rated 1200-A d.c. rectifier power unit, and the trailing head by a 1000-A a.c. transformer power unit, continuously rated at 800 A. A copper backing shoe is positioned on the underside of the joint underneath the welding heads, being mounted at the end of a cantilever arm suspended from the entry point of the seam welder. A circulating water system is used to cool the copper shoe. With the shoe in position, a completely penetrating weld can be made with the machine, which is equipped with a continuous circulating system for welding powder.

The internal welding equipment comprises a Unionmelt D.S.H. welding head with feed-roll and nozzle assembly for parallel electrode welding, mounted at the end of a boom 30 ft in length. The boom remains stationary while the pipe is moved at welding speeds on a traversing roller bed. The main part of the boom is substantially rigid, but the end is supported by small roller bearings on the bottom of the pipe. A closed-circuit television system is used to enable the operator to see the line of joint ahead of the welding nozzle, so that any adjustments can be made. Welding powder is carried in a hopper mounted at the end of the boom, whence it is fed by gravity to the weld zone. Unfused powder is picked up a short distance behind the welding nozzle by a vacuum suction unit mounted at the base of the boom, with a hose extending through the centre of the boom.



The principal advantage of the Torrance edge-forming and seam-welding equipment is that it feeds pipe continuously through the machine with the minimum of interruption of the welding procedure, enabling an overall duty cycle of 80 to 90% to be achieved. The machine has an additional feature, i.e., the forming rolls which break the plate edges as the pipe sections enter the machine. Considerable capital and labour costs are eliminated by the use of this method, since these rolls make it unnecessary to provide other machines (with their operators) for breaking the plate edges prior to rolling or press-forming.

Putting two and two together and making five ! At least, that's how it appears when you consider the saving in time and cost by changing over to tapping screws. Without doubt, the tapping screw does display a number of very definite advantages over the conventional machine screw. It obviates the use of nuts. With its self-locating point, it forms its own thread and eliminates a separate and expensive tapping operation. It makes for easier assembly, is stronger, cheaper and faster. And when used in conjunction with the Phillips recessed head, designed for power driving without damage to either work or worker, it is obviously safer. Putting two and two together, the tapping screw simply ensures a better job. Why not change over to tapping screws and prove it for yourself?

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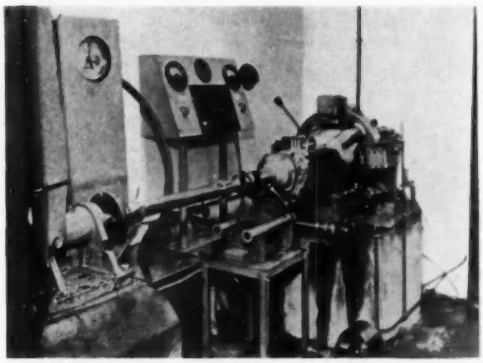
New Gearbox Test Plant

A new type of gearbox test plant, believed to be unique, has been installed by Jaguar Cars Limited in consultation with Heenan & Froude Limited, of Worcester. The plant has been designed to test gearboxes at varying speeds on all ratios, and to simulate actual road-test conditions as closely as possible, while permitting the operator to carry out his task speedily without the distractions which would normally be encountered on the roads.

The gearbox for test, together with a slave clutch unit, is positioned in a soundproof chamber, as shown in the illustration, and is driven by a variable-speed unit, its power output being abosrbed by another unit, both units being mounted outside the chamber, in the interests of silence, and connected to the gearbox by shafts passing through the chamber walls. The design of the plant provides for the gearbox to be tested under both " engine-driven " and " overrun " conditions. All controls are located inside the chamber and are arranged so that the operator can adjust speeds and loads instantly and with the minimum effort.



The gearbox is fixed in position by quick-acting clamps, and an air-operated hoist installed inside the test chamber enables the gearbox to be moved quickly into position and removed after test. The driving unit is a powerful, constant-speed a.c. motor, which, as it starts under no load, needs only the simplest of switchgear. The unit is connected to the gearbox from a Heenan-Dynamatic eddy-current coupling serving two purposes, i.e., in " engine-driving " tests it provides a variable speed drive to the gearbox, while under " overrun " conditions it absorbs the power reaching it from the gearbox. A similar unit identical with the first, except for its motor, which is of lower power, is coupled to the output shaft of the gearbox, both units being electronically controlled.

The normal test begins by driving the gearbox at a low speed and applying load to the output shaft, the speed being automatically held constant, despite any changes in load, at any particular setting of the motoring control handwheel. The operator may vary the speed from a crawl to maximum, apply any load required, and hold the speed as desired. For example, he can dwell as long as he considers necessary at any speed where he may suspect undue noise. On completion of the test on one gear ratio, the operator turns a switch on his control panel from " run " to " overrun ". This cuts out the speed-variation section of the eddy-current coupling of the main motor and brings into action its brake section. The same switch creates the opposite effect in the coupling at the output side of the gearbox. The output-side assembly is then used to test the gearbox by driving it from what is normally its output shaft and braking its input shaft, thus giving the same direction of torques and forces as when the car is driving the engine on the road.

As soon as the operator has checked the gearbox for run and overrun on one particular gear ratio, he changes into another ratio, and continues in this way until the gearbox has been tested in all gears. A foot-pedal, built into the rig and connected to the slave clutch, enables gear-changing to be carried out in the same way as on the road.

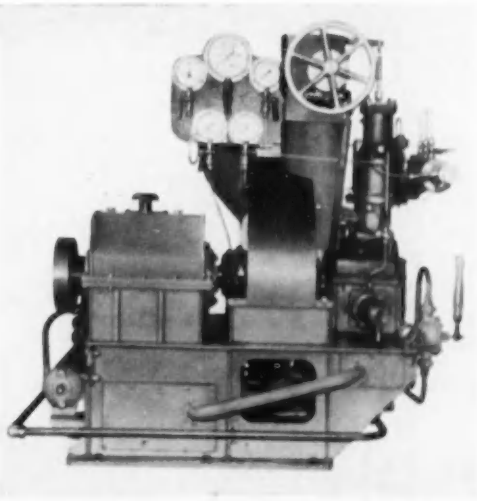
Both motors are run at full normal speed throughout the test, all speed variation at the gearbox being carried out by the couplings.

The test plant has been in operation sufficiently long for a fair assessment of its value to be made, and it is stated to have proved entirely successful, allowing the minimum loss of time in fitting and removing gearboxes, and in adjustment of speeds and loads. Furthermore, the high degree of silence prevailing in the test-chamber has permitted sound and consistent judgments of gearbox noise to be achieved.

Small High-Speed Geared Steam Turbines

A new range of small high-speed geared steam turbines, rated from 200 to 1000 hp, has been introduced by J. P. Hall & Sons Ltd., of Peterborough. The basic turbine remains unchanged throughout the range, with only detail differences to suit particular working conditions. Thus, for example, new nozzles and throttle valve seats can be supplied to adapt existing turbihes for modified working conditions. The fitting of these items is very simply carried out, and a turbine can be converted for altered steam and exhaust conditions very quickly.

The basic turbine is a velocity-compounded impulse type, mounted on a rigid fabricated combined frame and gearbox. All the latest techniques are incorporated, including the use of standard steel-backed white-metal journal bearings for the rotor and pinion shaft and for the gear shaft. These can be removed without lifting out the shaft, and replacements can be inserted without the need for scraping or hand fitting. A hydraulic constant-speed governing system, with manual speed-variation control, hand trip control at the turbine, forced lubrication with oil-circulation indicators, full-flow oil filter, oil cooler, overspeed trip device, relief valve, tachometer, pressure gauges, etc., form part of the standard equipment. Optional extra fittings include remote hydraulic speed-variation control, a remote-reading tachometer, a remote hydraulic-relay hand trip control, a low oil-pressure trip, a high-exhaust back-pressure trip, lagging, etc.



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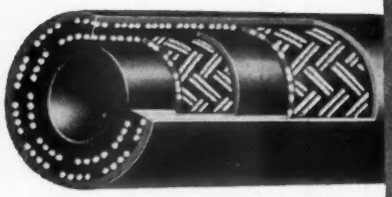
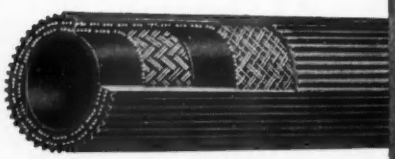


STYLE A *for service where oil mist may be present in the line, and where operating pressures up to 325 lbs. per sq. in. are used.*



STYLE B *for general, light and medium pneumatic tool service and working pressures up to 210 lbs. per sq. in.*

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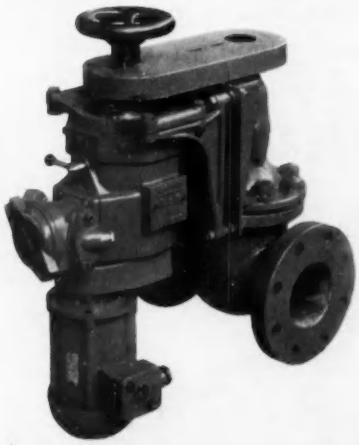
Typical applications of this new range of steam turbines include driving of pumps, compressors, fans, etc. They are suitable for exhausting either to vacuum or against back-pressures, and are especially applicable in oil-refinery installations or for driving mill machinery, where low-pressure steam is required.

Electric Servo-Motors for Motorization of Valves

In addition to their electric, pneumatic, and hydraulic servo-mechanisms, a range of electric servo-motors, specially developed for motorization of valves, is announced by the SADI Engineering Co. Ltd., of London, W.8. Equipped with standard or flame-proof electric motors, these units adapt themselves readily to new or existing valves and will actuate them at the speeds required for the conditions under which they are used. An example of such a servo-motor, designated type R.X., is given in the illustration which shows a high-pressure valve motorized with a size M/112/RBX.4, 0·35-hp, 72-rpm servo-motor.

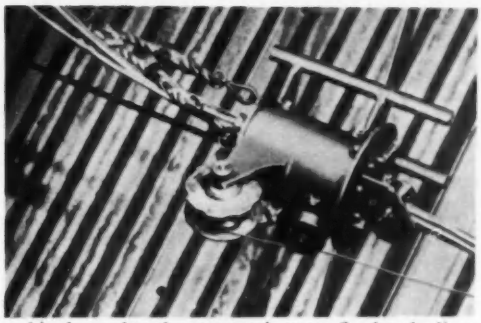


These motors are capable of undertaking efficiently all operations in connection with valves, including complete closure, automatic stoppage at the end of closing and opening travel, and application to the gate of a greater effort at the beginning of opening travel than at closing.

Small Cable-Spinner

Overhead catenary-supported cables in diameters up to 1 in. form a convenient means of medium-power distribution and of providing communication circuits between buildings on many types of site or in large workshops, where the cables can be run between the roof trusses. Existing cable-spinners tend to be too large for convenience in work of this kind, and Pirelli-General Cable Works Ltd. has therefore introduced a new 1-in. cable-spinner specifically for these applications, where portability and easy manipulation are of major importance.

The spinner consists of a rotating drum, on which is mounted the spool of wire for lashing the cable to the catenary. Two feet on the drum act as a counterblance to the spool when it rotates and also form a support for the spinner when on the ground. To prepare the spinner for use, the catenary and cable are threaded through the drum, and the spool of lashing wire is placed in position. The wire is then passed round a friction-wheel attached to the drum and bearing against the end-plate of the spinner,



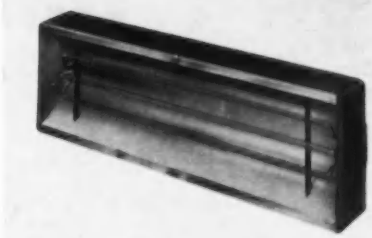
and is clamped to the catenary between fixed and adjustable rollers. When the catenary is in position between the supports of the span, the spinner is towed along it by hand. As the lashing wire is paid out from the spool, it causes the friction-wheel to rotate, so that it travels round the circumference of the end-plate and turns the drum, carrying the wire round the cable and the catenary in a spiral as the spinner moves forward along the span.

The illustration shows the cable-spinner in use for lashing four plastic cables to a catenary wire run high up inside a factory roof.

Infra-Red Projectors

Designed for general infra-red heating applications, such as paint stoving, moisture extraction, and preheating, the new improved range of Metrovick infra-red projectors with tubular metal-sheathed heating elements, introduced by the Metropolitan-Vickers Electrical Co. Ltd., of Trafford Park, Manchester, can be fitted end to end to form continuous troughs, assembled in banks, or used in angular formation to accommodate products of irregular shape. They can also be built into an enclosed plant or used as robust portable units on stands.

In these new models, the end and back covers are sturdy steel pressings with ventilation louvres, instead of perforations. These covers can be dispensed with in cases where close spacing, such as in enclosed ovens, is desirable. In addition, methods of supporting the projectors, which are available in lengths from 18 to 36 in., with corresponding loadings from 1·5 to 4 kW, have been simplified. Pressed-steel brackets, readily clipped into slots, now enable the units to be attached to 1-in. diameter conduit or bar ; alternatively, the slots can be used to bolt the projectors to angles or slotted angles. Conduit entry is catered for by a new type of fixing plate which enables the conduit to be attached by means of lock-nuts.



The efficient anodized-aluminium reflector and metal-sheathed element remain unchanged (apart from a more satisfactory method of supporting the element in the reflector), but the terminal arrangement has been improved by the use of nickel-plated steel bars, in place of copper rod, while a simple arrangement allows the projector to be converted for use on d.c. or single- and three-phase a.c. supplies.

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ADDITIONAL ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

A Theory for Preheating of Plain Low-Carbon Steels.
By E. P. DEGARMO. (From *The Welding Journal, U.S.A.*, Vol. 37, No. 3, March 1958, pp. 93s–96s, 4 illustrations.)

DESPITE the fact that several investigators have shown that proper preheating of weldments of low-carbon steel, made of plate not exceeding $\frac{3}{4}$ in. in thickness, produces a marked improvement in performance, and that this has been confirmed by considerable practical experience, there seems to be no doubt that preheating has not been used as widely as it deserves. A number of reasons could be cited for the apparent lack of acceptance of preheating in this connection, but one of special interest and importance is the fact that no completely satisfactory theory has been available to explain how preheating accomplishes the results it produces or to enable predictions to be made as to the conditions when preheating will or will not work.

The object of this paper is to attempt to develop a theory explaining why preheating works. Naturally, it would be desirable if complete experimental proof of the theory could also be presented, but this unfortunately cannot be done, as it seems certain that research of the type needed will have a considerable statistical element, thus requiring rather extensive tests.

The paper considers six possible effects of preheating, i.e., reduced microhardness, increased width of the heat-affected zone, reduced shrinkage stresses, changed hydrogen content, more favourable microstructure, and reduced microcracking, and it is shown that the results of recent research rule out all these effects, with the exception of reduced microcracking, as possible primary causes of the improvement resulting from preheating. From a consideration of the requirements for microcracking, i.e., retained austenite and hydrogen, a theory is developed which states that it is the elimination of retained austenite at low temperatures, due to the greatly reduced cooling rate below 400°F resulting from preheating, that accounts for the beneficial results obtained. Based on this theory, certain conditions are indicated for which preheating will and will not produce improved performance.

The Effect of Preloading on the Yield Point of Iron.
By M. M. HUTCHISON and N. LOUAT. (From *Acta Metallurgica, U.S.A.*, Vol. 6, No. 1, January 1958, pp. 8–12, 4 illustrations.)

ACCORDING to Cottrell, a possible explanation of the yielding of polycrystalline metals in which dislocations are anchored is that dislocations in a few grains favourably situated, as regards orientation and localized stress concentrations, are pulled from their atmospheres at low stress and pile up at obstacles such as grain boundaries, mosaic boundaries, etc. As the stress is increased, more dislocations from the operative sources pile up until the stress generated is so high that a "break-through" occurs. Dislocations in neighbouring grains are torn from their atmospheres and the process becomes catastrophic. On the other hand, Louat has recently suggested that yielding follows immediately a source operates and that, prior to the operation, dislocations everywhere bend under the action of the applied stress.

One experimental phenomenon which might be expected to distinguish between these two theories of yielding is the effect of preloading on yield point. It has been shown that the yield point of single crystals of pure iron and of polycrystalline mild steel may be increased by protracted preloading below the yield point. Similar effects have been observed in polycrystalline mild steel, using stress pulse loading and subsequent annealing. On inspection, it was found that these experimental results were not sufficiently critical to discriminate between these views. Hence, further experiments on these lines were undertaken and the results are presented in this paper.

The results of this investigation have led to the conclusion that, with either theory, the yield point will be increased by preloading and that the amount of this increase is roughly equal to the difference between the preload stress and another stress which is characteristic of the material and the preloading temperature. On two other questions, i.e., (1) the result of repeated preloading, and (2) the effect of prolonged ageing without load after preloading, the Cottrell and Louat models lead to divergent predictions. In both cases, the experimental results favour a model in which the rise in yield is caused by the bending of the sources. While these results indicate that the model employed by Louat is to be preferred, it has not yet been shown that it is an accurate representation of the processes involved. Further work is being undertaken in an attempt to obtain more precise information.

Plastic Design of Rotating Discs.
By J. HEYMAN. (From an advance copy of a paper submitted to *The Institution of Mechanical Engineers, London*, March 1958, 13 pages, 17 illustrations.)

THE calculation of turbine discs normally entails the solution of a second-order differential equation involving an elastic stress function. This equation is integrable analytically for discs of constant thickness and for specific examples of discs of non-constant thickness. Other disc profiles may be introduced into the basic differential equation, provided that numerical integration is used. Even with an exact solution, however, the practical calculation of a disc is likely to be a matter of trial and error, recourse being made to tabulated functions. It is usual to assume a profile and, starting from the known conditions of edge loading, to work towards the hub by a step-by-step process in order to determine the maximum stresses. If these stresses exceed those permitted, a new profile must be assumed and the calculations repeated.

The permissible stress is some proportion of the yield or ultimate stress of the material used, and, as such, it incorporates a safety factor. This safety factor is supposed, presumably, to provide a margin against accidental overspeed of the disc. For a disc of non-uniform profile, however, the fact that the hoop stress at the hub does not exceed the permissible value tells the designer little more than that the disc is safe at the design speed, and he cannot, from this knowledge alone, calculate the percentage overspeed at which the disc will burst, or, more realistically, at which the diameter of the disc will increase sufficiently to strip the blades. Since the overspeed condition is the one actually to cause failure of the turbine or compressor, it would appear more rational to examine the state of the disc at collapse, and, in fact, to design the disc to collapse at a certain percentage overspeed. The safety factor on stress is thus replaced in design by a safety factor on speed.

If, therefore, as described in this paper, attention is confined to the condition at which the disc is on the point of collapse, i.e., at which the whole of the disc has just become plastic, the problem is simplified considerably. Instead of using an elastic safety factor on stress, an overspeed factor is used; moreover, as one of the stress com-

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UH 24

ponents is known at collapse, only a first-order differential equation has to be investigated. This plastic design method will lead to profiles similar to those given by elastic design, but the calculations are much more rapid. A fully worked design example is given in the paper.

Reheat Practice in British Power Stations.

By F. H. S. BROWN and J. W. H. DORE. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, March 7, 1958, 19 pages, 9 illustrations.)

THE factors affecting the choice of plant for large generating systems such as that of the Central Electricity Generating Board are of some complexity. The fundamental objective is, of course, the provision of an adequate and continuous supply of electricity to the consumer at as low a price as possible, and it will be appreciated that this is not necessarily identical with the attainment of maximum thermal efficiency at the power stations. In this paper, however, no attempt is made to consider the whole problem of selection of types of generating plant, but the problems which have arisen in the development of the large reheat units on which the Board's current plans for new generating capacity are based are discussed broadly, and the solutions to those problems which have been adopted are described.

The Central Electricity Generating Board's current plans for new generating capacity using fossil fuels are based on the use of large boiler-turbine units in which reheating of the steam after initial expansion is employed. The background to the development of these units is reviewed, and the ways in which the use of reheat affects the design of the main items of plant, the significance of unit rating and its influence on design, and the special requirements imposed by the need for the plant to be suitable for two-shift operation are considered. Reference is also made to certain aspects of the design of generators and of some items of auxiliary equipment which, although not related to the use of reheat, are very much a part of current practice. Some of the problems encountered in the evolution of the latest designs are discussed, and descriptions are given of the solutions which have been currently adopted.

Investigations of Natural Circulation in an Experimental Two-Tube Boiler.

By A. M. LAIRD, A. W. SCOTT, and A. S. T. THOMSON. (From a paper presented at a meeting of the *North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne*, March 7, 1958, pp. 311–340, 17 illustrations.)

SINCE water-tube boilers were first introduced, it has, of course, been recognized that successful operation depends on the maintenance of adequate circulation, and the first published papers dealing with the factors governing circulation appeared some sixty years ago. In these early publications, discussion was based upon experience and observation, with little reference to experimental work, and use was made of model-scale plant, but lack of control over test conditions and defects in measuring technique led to contradictory conclusions. Nevertheless, at this early date, it was established in a qualitative manner that circulation rates were affected by changes in pressure, in heating rate, and in the diameter, length, and inclination of the tubes.

After surveying the published work in this field, the British Shipbuilding Research Association decided to build a full-scale experimental two-tube boiler for further research into the principles of natural circulation. This paper presents a description of the plant and some results of the work already done. After describing the boiler, which is designed for a maximum pressure of 1500 psi and a maximum heat-input rate of 120,000 BTU/hr ft², and for which provision is made for varying tube diameter, length, and inclination, details of instrumentation are given. The paper then deals mainly with the presentation of experimental results and briefly mentions the correlation of these results with theory. The results reported all relate to vertical tubes. The main series show the influence of tube diameter, pressure, and heat-input rate on circulation velocities, and additional tests indicate the effects of restricting orifices in the circuit, non-uniform heating of the riser, shortening the heated length, and rapid drop in boiler pressure. Under steady operation, natural circulation is more than adequate to deal with the maximum heat loading and evaporation rate attained in these tests ; tube diameter has an important influence on circulation rate at all conditions within the range studied. At pressures above 400 psi and heat-input rates in excess of 40,000 BTU/hr ft², changes in pressure and heat-input rate become relatively less important. A non-uniformity of heating around the riser tube is unimportant. The rate of drop in pressure to produce circulation failure is related to boiler pressure and to the circulation velocity obtaining before pressure drop occurs.

Difficulties arise in correlating results, owing to lack of information regarding the component factors affecting circuit resistance. Measurement of density and determination of flow pattern in the riser tube by the gamma-ray technique, described in the paper, should provide much of this information.

The Effect of the Base Metal on the Thermal Life of Enamelled Magnet Wire.

By J. H. THOMAS and J. F. DEXTER. (From *Power Apparatus and Systems (A.I.E.E.), U.S.A.*, No. 33, December 1957, pp. 1009–1013, 9 illustrations.

IT is well known that copper oxidizes at high temperatures. Unlike the tenacious oxide film on aluminium, the copper-oxide film has poor adhesion to the base copper. Magnet-wire enamels coated on copper wire, therefore, tend to lose their adhesion to the wire after ageing at high temperatures, and this loss of adhesion decreases its effective life. When the reinforcing action provided by the enamel-copper bond is lost, mechanical stresses, due to thermal shock, vibration, and embrittlement of the enamel, are no longer uniformly distributed along the wire surface. The enamel will then crack at points of stress concentration.

In this paper, the results of thermal ageing tests of a modified silicone enamel coated on several different wire materials are reviewed. In setting up this programme, no attempt has been made to study the effects of many different metals, the major objective being to observe the effect of the wire material on the life of the enamel and not to determine the best wire material.

The improvement in thermal life of a particular wire enamel coated on several different wires is given. These data show that, at temperatures above 200 °C, significant increases in thermal life can be expected when the base copper wire is protected. Data should be obtained at lower temperatures. However, since, even at 200 °C, life values of several years are anticipated, very long tests must be made.

An economical and practical method for protecting copper wire by applying a thin coating of aluminium paint is described. Not only is this coating effective in prolonging the life of enamelled wire, but it has further advantages. Unlike nickel-clad or other plated metallic coatings, the thin coating of aluminium paint does not decrease appreciably the conductivity of wire, and it can be applied to the wire on conventional magnet-wire-coating equipment, simultaneously with the enamel or in a separate operation. There is no problem in making soldered or brazed connections in the wire, as the aluminium paint can be removed by scraping.

It appears that copper oxidation becomes less of a problem at temperatures below 200 °C. The longer life of modified silicone enamel afforded by a protective coating on copper wire may make possible its use at higher temperatures, especially in those cases where only limited life is desired.

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* *Figure supplied by Gt. Raymond Paper Co. of Lac Brûlé, Canada.*

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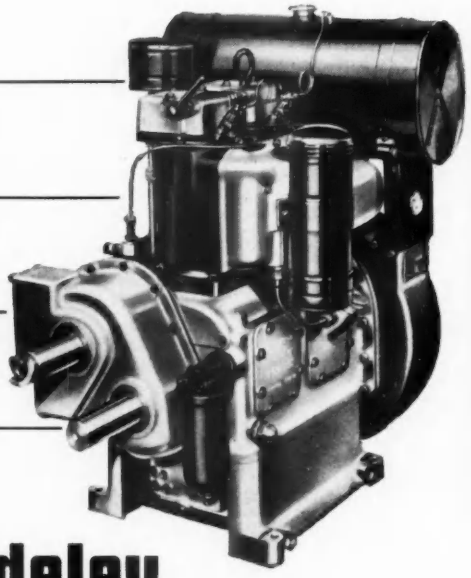

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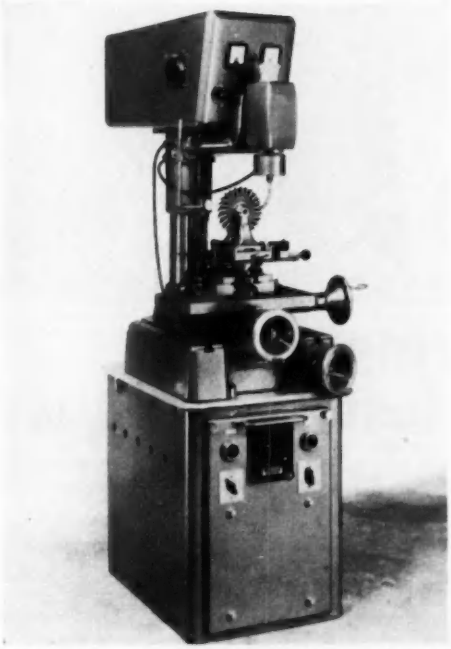
Based on the discovery that, under certain electrical conditions, electrode material can be transferred from the tool electrode to the workpiece when spark-machining with their " Sparcatron " machine, a spark-hardening machine, designated the " Sparcard ", for the surface treatment of high-speed steels is announced by Impregnated Diamond Products Limited, of Gloucester.

Basically, the electrical parameters of the " Sparcard " circuit are very similar to those of the " Sparcatron ", the major difference between these machines being that, in the " Sparcard ", a vibrator is used in place of a servo-head. The cabinet base of the machine houses the transformer and other power-supply equipment, while the condensers and the output side of the circuit are accommodated in the head, which is also provided with a voltmeter, ammeter, and the switches controlling the spark discharge. The vibrator is situated immediately below the head and is provided with a clamp to hold the electrode, which is usually of tungsten carbide, and a micrometer depth control for fine adjustment of the electrode while working. Coarse control is effected by a hand-wheel.



The main worktable is provided with tee-slots and on it rests the compound table, which is of conventional design with V-slides, giving a longitudinal movement of 12 in. and a transverse movement of 6¼ in., both movements being operated by a hand-wheel. A universal tool holder for single-point tools, reamers, and milling tools is provided and will take milling tools of up to 8 in. in diameter. The work-head is mounted on a column and is so arranged that it can be swung out of the way during setting up of the work. A clamp is provided for locking the head firmly during operation.

The workpiece, which should be ground and must be free from dirt, oil, or grease, is mounted in the tool holder, the electrode is brought into contact with it, the current is switched on, and the electrode is traversed across the surface to be treated. The spark discharge is regulated by means of a rheostat, using the ammeter and the voltmeter to maintain a constant condition. Four settings of condenser power are provided to treat tools for heavy, medium, or fine finish. In practice, the tool face which will suffer the worst wear is treated, and this is usually the top rake where chip erosion is felt. However, when front rake wear is heavy, it is often advisable to treat this area. Minor irregularities in the tool surface are automatically compensated by means of an adjustment made to the amplitude of the vibrator oscillation.

The treated surface is composed of a multitude of shallow craters of satin-like appearance to the naked eye. Photomicrographs reveal that these craters are lined with hard metal and that the hardening effect penetrates deep into the sub-surface zone. When tool steel is treated, a sandwich effect is created where the surface and immediate sub-surface zones are hardened ; below this is a soft zone and below this again the parent metal.

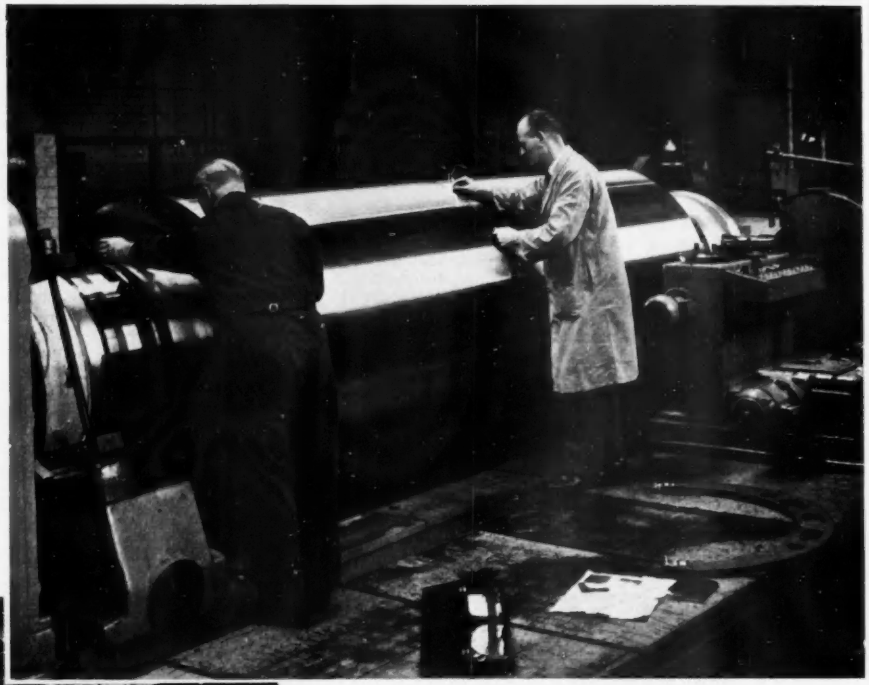
AUTOMATIC TRACER LATHES FOR COMBINED ROUGH- AND FINISH-TURNING OF SHAFTS

Completely automatic tracer lathes, designed for high-level performance in the rough- and finish-turning of shafts, have been developed by The Seneca Falls Machine Company, of Seneca Falls, N.Y. Designated models LQ and AQ, these lathes combine the advantages of multiple tooling for rapid stock removal and single-tool tracer turning for accurate finishing operations. The work of the operator is confined to loading the shaft between centres and pushing the starting button, after which the multiple tools turn, then retract, and the tracer tool finish-turns and retracts to the starting position, leaving the machine ready for reloading.

Multiple tools, mounted on a rear carriage, accomplish the roughing operation, while finish-turning is effected with a single tracer-controlled tool on one or more overhead carriages. This method permits extremely close tolerances, since the pressure of the tool is constant over the entire length of the workpiece and enables full advantage to be taken of the higher cutting speeds now possible with carbide- and oxide-tool materials. The electro-mechanical tracer unit on these lathes responds very rapidly and with great fidelity to dimensional changes in the template. Idle time is reduced to a minimum by forward and reverse rapid traverse with a tracer slide. Rapid traverse movement is independent of the tracer system and is automatically operated by electric clutches through contactors mounted on the control drum. The carriages are available in five combinations, i.e., (1) an overhead left-hand tracer carriage, tracing from headstock to tailstock, and a right-hand tracer from tailstock to headstock ; (2) a right-hand tracer and multiple-tool carriage ; (3) two right-hand tracers and two multiple-tool carriages ; (4) two right-hand tracers and two squaring or necking carriages ; and (5) a left-hand tracer and left-hand multiple-tool carriage.

Feed rate may be changed automatically during the cutting cycle. Chip disposal may be handled by any one of three methods, i.e., the floor underneath the machine may be cut away for the chips to fall through onto a central chip conveyor ; (2) roll-away pans may be fitted underneath the bed of the machine ; and (3) individually motorized chip conveyors may be installed underneath the bed and arranged to evacuate the chips into tote-boxes. In addition, the lathes are designed for efficient

The latest techniques in the rolling mill



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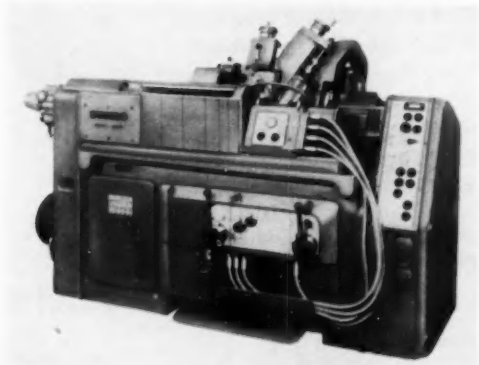
chip guarding, and all templates are clear of chip areas, while the open-front design facilitates manual or automatic loading and unloading.

Tool adjustment is extremely rapid. Diameter and shoulder-length accuracy is controlled by the stylus, which is adjusted by means of compound slides operating in conjunction with two dial gauges. The operator merely takes an initial cut over the workpiece and sets the dials to zero. The workpiece is then checked with micrometers for out-of-tolerance readings and the stylus is accurately adjusted by turning slide-adjustment knobs until the hands on the dials indicate the correct amount of stock removal. After the stylus is adjusted for size and length, the hands on the dials are again set to zero and the first piece turned is accurately machined to the specified dimensions. Dial gauges also give visual indication of tool adjustment for wear and permit resetting the stylus to zero when the tool insert is indexed or changed for a new cutting edge. Convenient control stops permit quick synchronization of all longitudinal and cross feed movements, as well as the rapid traverse of carriages and cross slides.

HYDRAULIC COPYING LATHES

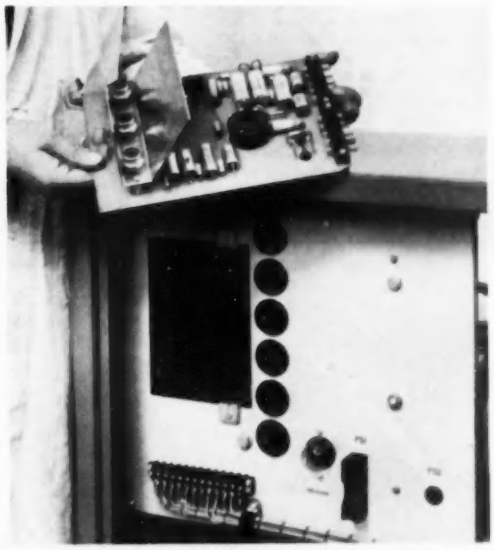
Two new hydraulic copying lathes, type 517 and type 517r6, are announced by Edouard Dubied & Cie. S.A., of Neuchatel, Switzerland. These machines, which were exhibited for the first time at the recent Swiss Industries Fair, are built on the unit-construction principle, so that they can be supplied to suit individual requirements and can be adapted, as necessary, to changing production conditions. The copying slide has been transferred to the rear, but is still accessible. The design of the bed, inclined to the rear for chip evacuation, has been maintained. Bearing in mind the possibility of large-scale application of ceramic tools, all components have been built to obtain maximum rigidity. The spindle is driven by a motor of 9 to 11 hp, and the hydraulic unit, coolant supply pump, and fan are each fitted with its own drive motor.



The type 517r6 machine has been developed as a semi-automatic lathe, an automatic cycle of six successive cuts being initiated by a push-button. This machine also permits selection of four different feeds which change automatically, depending on the quality of the surfaces required. The hydraulic clamping devices for the headstock and tailstock are pedal-operated, enabling the operator to use both hands for changing workpieces.

TRANSISTORIZED AND PACKAGED WARD-LEONARD VARIABLE-SPEED DRIVE

Believed to be the first commercial application of transistors to the control of electrical machines, the new "Transidyne" transistorized Ward-Leonard variable-speed drive, shown by Lancashire Dynamo Electronic Products Ltd. at the recent Electrical Engineers' Exhibition, is packaged for ease of application and installation, and uses a Ward-Leonard motor-generator set power converter providing regenerative braking and stored energy for rapid acceleration without transient supply loads.



The use of transistors provides a simple rugged drive with a high-performance closed-loop servo-control of speed. In addition, as shown in the illustration, these units, which are available in capacities from 1 to 10 hp, with three sizes of cubicle, incorporate control circuits of standardized plug-in printed-circuit card construction, while the whole cubicle is cooled with filtered air circulation by the blower of the motor generator set.

NEW PROCESS FOR ELECTRO-REFINING NICKEL

An important feature of the new process developed by The International Nickel Company of Canada, Limited, for the electro-refining of nickel is the direct electrolysis of nickel matte and artificial sulphide. This feature contrasts with the usual electro-refining methods, including those employed in the nickel industry, in which a metal anode is used.

This new Inco process eliminates high-temperature oxidation and reduction operations, with the attendant losses of metals and of sulphur and selenium. Instead, nickel sulphide of low copper content from the Bessemer converter or other source can be cast directly into sul-

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phide anodes and electroysed for the production of high-quality nickel. Another unique feature of the process is that it permits, for the first time in nickel refining, the commercial recovery of elemental sulphur and sulphur, in addition to the cobalt and precious metals normally recovered.

The process, for which Canadian and United States patents are pending, is in commercial operation in a section of the company's nickel refinery at Port Colborne, Ontario. Sulphur-selenium separation is accomplished in a specially designed fractionating column, 100 ft in height.

LIGHTWEIGHT STAIR-CLIMBING HAND-TRUCK

A new lightweight hand-truck, incorporating special retractable tracks for enabling it to negotiate stairs with ease, is announced by Industrial Trucks Ltd., of London, W.3. Known as the " Stepmaster ", the truck, which was exhibited at the recent Factory Equipment Exhibition, is very strong and can carry loads up to 1 cwt, though it can be handled quite easily by one man, as it is constructed of specially designed sections of high-duty aluminium alloy.

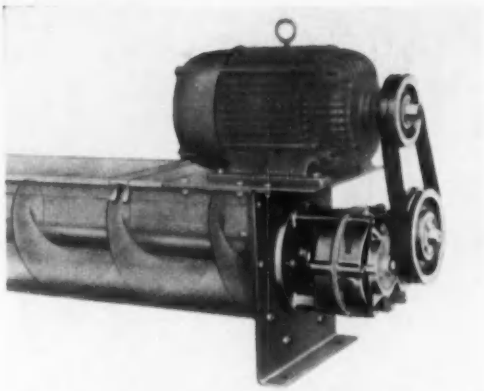
On level surfaces, the tracks are retracted, and the truck rolls on 8-in. diameter cushioned-tyre wheels with roller bearings. For negotiating steps or stairs, the tracks are lowered into position by operation of a simple lever catch, gripping the steps, as shown in the illustration.

SCREW-CONVEYOR DRIVE UNITS

A new range of screw-conveyor drive units, capable of simple mounting and adjustment on standard conveyor troughs, has been developed by The Dodge Manufacturing Corporation, of Mishawaka, Indiana. Basically comprising a speed reducer with a packing gland and drive shaft, mounted on the trough end, these units are available in four sizes, covering 95% of industrial requirements, and each unit can be supplied with two ratios, i.e., 18 : 1 and 8 : 1.

The design of these drives is such that maximum protection is afforded to the unit against entry of material handled by the screw conveyor. The packing gland is adjustable from the outside, takes standard packing materials, and can be inspected easily and quickly. A flinger seal on the shaft, adjacent to the speed reducer, also prevents liquids or other foreign matter from reaching the reducer seals, which are of the double-lip type for additional protection.

Simplicity and economy are achieved by elimination of the conventional sliding motor base. Instead, slotted holes in the flange of the reducer are provided, permitting the unit to be rotated for rapid and easy adjustment of centre distance of the V-belt drive. Both the motor and the drive may be mounted in any position, and the use of heavy-duty taper roller bearings, which take thrust in either direction, eliminates the need for a separate thrust bearing. The reducer, complete with packing gland and

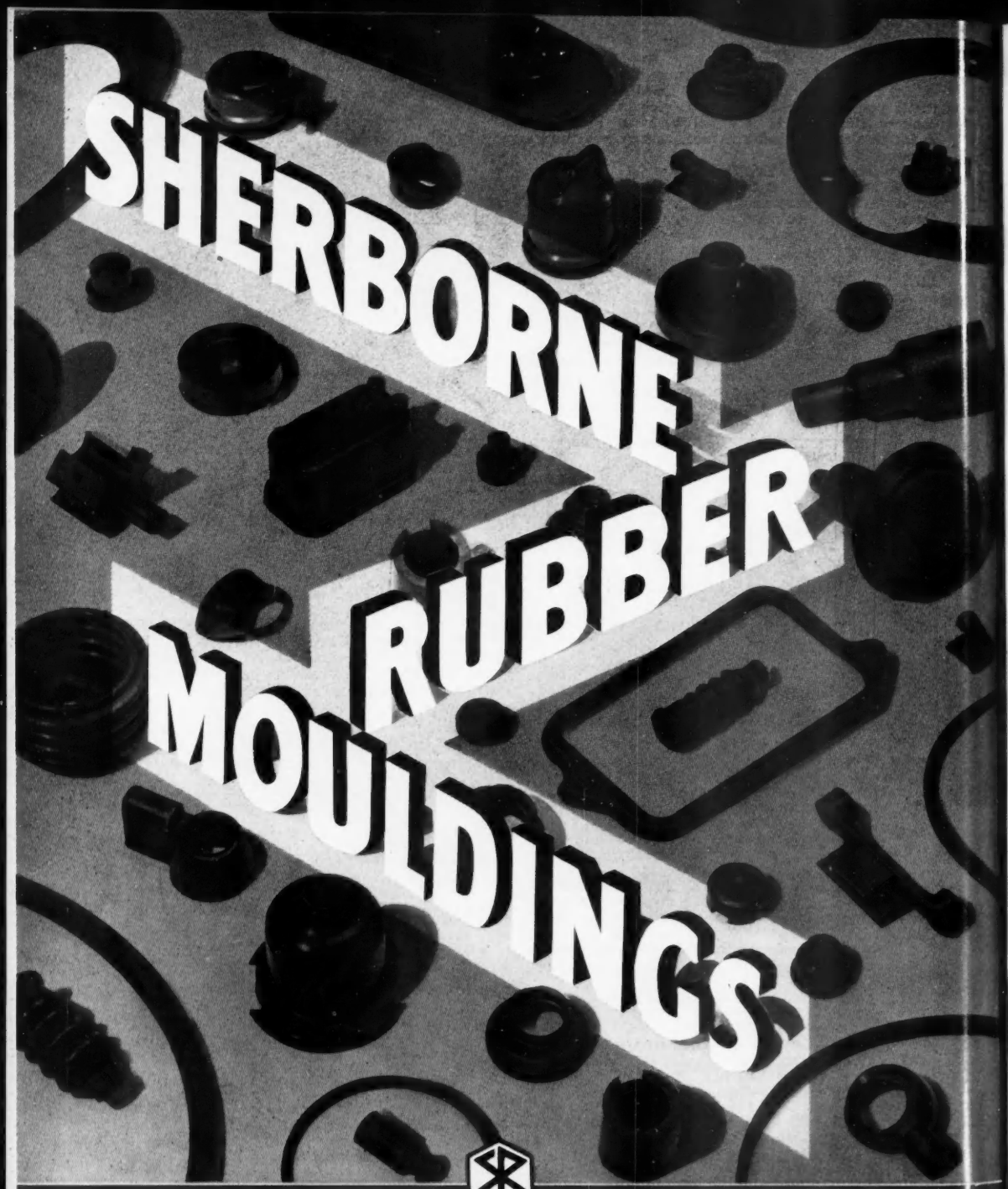


drive shaft, can easily be mounted on or removed from the trough by means of three bolts in the reducer flange. The drive shaft is mounted in a steel sleeve, and a built-in puller facilitates changing the shaft without having to open up the reducer itself.

HIGH-FREQUENCY P.V.C. WELDING MACHINE

The new No. 1 " Acme " high-frequency P.V.C. welding machine announced by H. F. Industrial Services Ltd., of London, N.22, is capable, with the use of interchangeable platens and tools, of meeting almost any requirement likely to be called for in the use of polyvinyl chloride. In addition, it is stated that the problem of " flash " has been completely solved with the new machine, so much so that, even with tear-seal electrodes completely overhanging the work by as much as 6 in., no burn or flash whatsoever is produced.

The machine, which is rated at 1·5 kW, is compact and mounted on castors for greater mobility. Operation is by foot-pedal, the stroke of which can easily be adjusted to suit individual operators, thereby reducing fatigue in cases where long repetition runs are involved. An outstanding feature is the incorporation of a precision-built press which has been specially designed to exert pressures up to 400 lb—a considerable increase over other methods. Another feature is a special work-lamp which, apart from a red pilot-light to indicate when current is switched on, becomes illuminated when the machine is warmed up and



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ready for operation, and which is extinguished on completion of the weld cycle. Furthermore, the built-in resettable counting unit has been so arranged that only complete welds are recorded.

Sets of interchangeable parts, e.g., top mounts for the press and platens for the bottom, make it possible for an unusually wide range of sizes and types of work to be carried out on the standard machine, modifications required for change-over being effected quickly and easily.

The depth of penetration is micrometer-controlled up to 0·001 in. As an example of the performance of the machine, which is also suitable for welding cellulose acetate, it is stated that it will weld a 10-sq in. area or 80 linear inches on two thicknesses of 0·018-in. P.V.C. in 5 sec. Welding power is easily adjusted, and no tuning is necessary.

MAGNETIC-PARTICLE COUPLINGS FOR INDUSTRIAL DRIVES

The new magnetic-particle couplings for industrial drives to be shown for the first time at the forthcoming Mechanical Handling and Production Engineering Exhibition by S. Smith & Sons (England) Limited, of Witney, Oxfordshire, are electromagnetic couplings which combine the resilience of their fluid-flywheel counterpart with the stability of solid devices. They are constant-torque units and incorporate a safety feature which permits a certain amount of slip, when necessary. These couplings, which have no moving engaging components, are available with torque capacities ranging from ¼ up to 200 lb-ft in a range of eight sizes, and operate from 24 or 180 V d.c. as standard, though special voltages can be catered for, where required. Model SFU.550/50, with an output member of 5½ in. diameter and a torque capacity of 50 lb-ft, is illustrated in Fig. 1.

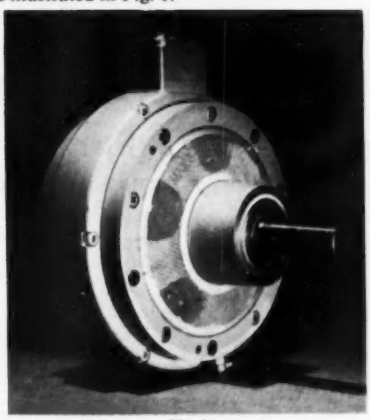


Fig. 1.

The coupling contains two rotors, one within the other, but separated by an air gap, one rotor being coupled to the input shaft, and the other to the output shaft. The air gap contains a quantity of ferromagnetic powder, and around the two rotors is a stationary field member containing an exciting coil, with an air gap between it and the input rotor. When current is applied to the coil, magnetic flux is created which crosses the air gap between the stationary member and the input rotor, and the powder gap between the input and output rotors. When the flux passes through the powder, the particles are attracted between the pole faces in such a way that torque, proportional to the degree of excitation, is transmitted from the input to output rotors. During the take-off period, the coupling operates with a smoothness and an absence of jerk or judder met only in hydraulic devices. On the other hand, under full excitation, the coupling will become solid, without slip and therefore without generation of heat or loss of efficiency.

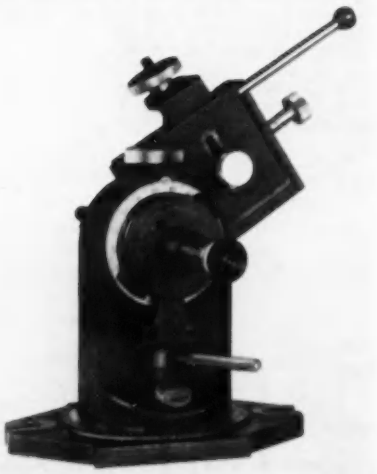
Fig. 2.

The components of the model SFU.550/50 coupling are shown in Fig. 2. The stationary field member, with its winding can be seen in the left background. The shafts in the centre carry (right) the input member, and (left) the output member and the back-plate for the input member. Thus, when assembled, the output member is fully enclosed, and the input-member back-plate has integral with it a labyrinth plate to keep the magnetic powder in its working area.

TOOL-RADIUS AND CUTTING-EDGE GRINDING ATTACHMENT

Originally designed by the Production Engineers Research Association, with optical equipment supplied by C. Baker of Holborn Ltd., London, who have now undertaken production of the whole unit on a commercial basis, the Baker-Pera tool-radius and cutting-edge grinding attachment fits readily on existing machines with the normal cutter grinding table and spindle, as shown in the illustration.

A plain base is ground for placing the magnetic chucks and has slotted lugs for tee-bolting to machine tables. In the base a pillar is centrally spigoted and is fitted with a central lever-operated clamp. A horizontal scale is marked on a bevel at the base of the pillar and registers with a setting line inscribed on the base. On the same centre-line as the base spigot and at right-angles to it, the pillar is bored to accept the tool-carrier plate and the optical system, ensuring that the tool carrier revolves about the optical centre of the microscope.



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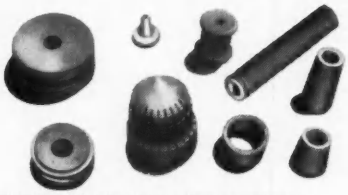

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A second scale is carried on the horizontal sleeve which supports the tool carrier plate in the pillar, and the setting line is inscribed on the pillar. To enable the carrier to be moved around its axis over a predetermined arc, two adjustable stops are fitted in a groove in the collar. These stops register with a fixed plate below the collar and can be set to the side-cutting and plan relief angles. In addition to the stops, a clamp is provided on the top of the pillar, so that the carrier plate may be locked in any position.

The tool-holder plate supports a cross slide with screw adjustments in two planes at right-angles. The tool to be ground is supported on a guide strip on the face of the cross-slide table and secured by a lever-nut clamp. Large tools are clamped directly to the table but, in the case of smaller turning and similar tools, a secondary holder is provided. Where the plan relief angle is required to be more than 30 deg., a supplementary plate may be used.

The optical system is a simple low-power microscope mounted in a ground-steel sleeve. The optical and mechanical axes are coincident, so that, when mounted in the rotary bearing of the tool-carrier plate, the field of view is concentrically disposed to the axis of the bearing. A target graticule placed in the microscope has concentric rings which are numbered and correspond to radii in increments of 0·005 in. The microscope may be focused on the tool tip, and the radius at the nose of the tool clearly observed against the graticule.

The capacity of the attachment is suitable for large tools up to 1½-in. square shanks. The small-tool auxiliary carrier will take tool shanks up to ⅝ in. square. The target in the optical system is marked in increments of 0·005 in. radius and provides direct comparative setting from 0·005 to 0·10 in. radius.

MERCURY-OPERATED INDICATING TEMPERATURE CONTROLLER

Believed to be one of the first instruments of its kind to be styled for appearance and to harmonize with the new trends in machine design, a new industrial mercury-operated indicating temperature controller, introduced by The Partlow Corporation, of New Hartford, N.Y., features a dual mounting design and greatly improved readability, combined with high accuracy. The new controller, designated model MFS, is available in ten different scale ranges and is capable of sensing, indicating, and controlling processes and appliances between —30 and +1100°F, with an accuracy of 0·5% of scale range.

Incorporated into the instrument is an exclusive feature, called " Accu-Vision ", which is stated to guarantee accuracy in setting and reading and virtually to eliminate the possibility of human error. This feature includes the use of an increased dial area, a special magnifying setting-pointer equipped with two hairlines for parallax sighting, and an optically designed combination of dial colours for the greatest possible contrast. Another exclusive feature is a special mounting arrangement which permits the case to be either flush- or wall-mounted without the need for additional mounting brackets or other hardware. Furthermore, the contours of the case, which incorporates a camera-type seal against dust and moisture, also permit mounting to be effected entirely from the front of the panel.

TOOL FOR FITTING AND REMOVING HOSE CLIPS

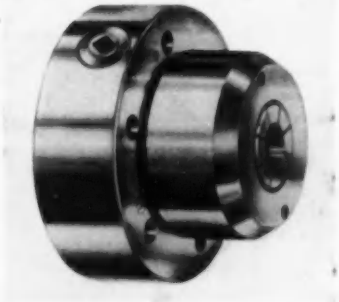
Incorporating a specially hardened spring-loaded screwdriver bit which enables hose slips to be gripped firmly while the adjusting screw is tightened or released, a new hose-clip tool announced by J. W. Pickavant & Co. Ltd., of Birmingham, is designed to aid in the speedy and safe fitting and removal of hose clips of the Cheyney, Collier, Jubilee, Terry, and similar types.

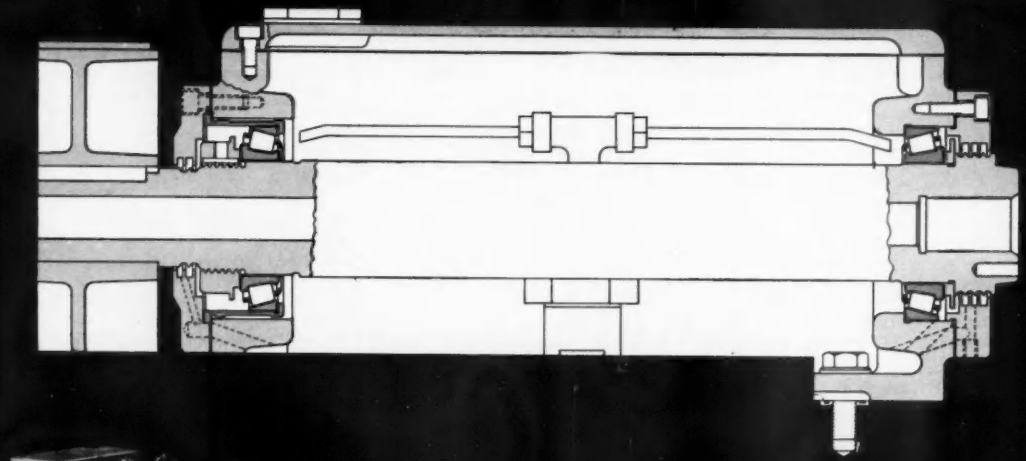
This latest addition to the " Apkoway " range of tools produced by the company is easier to use than an ordinary screwdriver. In addition, it saves time and eliminates the danger of injury caused by slipping. The tool, which is 9 in. in length and weighs only 6 oz, has a bright nickel finish as a protection against rust.

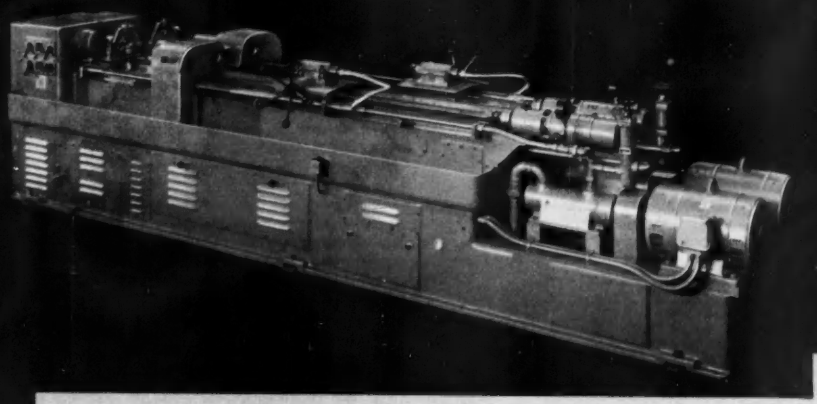
SELF-CONTAINED HYDRAULIC COLLET CHUCK

Claimed to be the most powerful dead-length chuck in existence, the new hydraulic collet chuck announced by Crawford Collets Ltd., of Witney, Oxfordshire, includes a self-contained and extremely powerful hydraulic system for providing the power for efficient closing of the collets. Intended to be used in conjunction with " Multibore " collets, the chuck has very few moving parts, and does not make use of gearwheels, pinions, toggles, balls, cams, or other parts likely to wear.

The great advantage is that each " Multibore " collet has a sufficient range (⅛ in.) to replace at least ten ordinary collets, including metric sizes, whilst still maintaining concentricity over the whole range. The extra-long bearing surfaces of the collet jaws remain parallel and in







The S.I.G. barrel drilling machine

This special-purpose machine is built by Schweizerische Industrie-Gesellschaft Neuhausen am Rheinfall: it is a duplex machine for deep-hole drilling rifle, pistol and machine-gun barrels, and shafts, spindles and similar work. The drilling capacity is from ·2″ to ·65″d., to a maximum depth of 31½″; the height of centres over the bed is 4″ and the swing 9½″.

The machine has an infinitely variable feed, and from ·2″ to 10″ per min. and the main spindle speed is 1350 to 6000 r.p.m.; it runs on Timken tapered-roller bearings, with special sleeve mounting for the bearing cup remote from the main support bearing. This mounting, which has proved extremely successful in many applications, relieves the bearing of excessive loads due to thermal effects, by permitting a limited degree of radial expansion under the end-load resolved by the cup angle.

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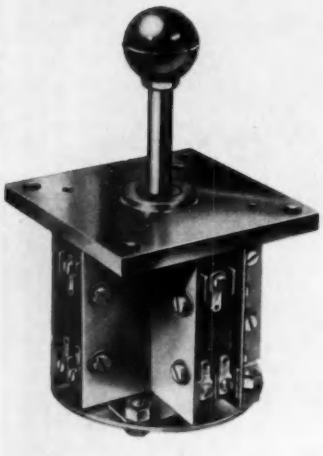
full contact with the workpiece throughout their size limits, while the collets themselves add the benefits of non-clogging to the normal advantages of blade-type collets.

These chucks can be used for gripping either bar or very short pieces in round, hexagon, or square materials. A high degree of accuracy is achieved, even when machining short workpieces, as an adjustable rear collet support enables components to be gripped firmly at the mouth of the collet, without mouthing of the collet bell.

FOUR-POSITION JOYSTICK-TYPE SELECTOR SWITCHES

Suitable for any application requiring manual control of more than one function, the new four-position joystick-type selector switches announced by the Switch Division of Pye Ltd., of Burgess Hill, Sussex, are designed to replace in one unit a number of individual push-button switches, thereby saving panel space. Operation of the joystick actuates four single-pole, double-throw change-over switches, controlling four independent circuits.



Occupying a space of 3 × 3 in., these switches can be provided, as desired, with an automatic spring return to the central " off " position (dead-man's handle arrangement), or a manual return to the " off " position, so that the joystick can be left in any selected position. A gate is provided to prevent more than one switch from being selected at a time. Individual replacement switches can be fitted quickly and easily, when required. These units are of extremely robust construction, with the joystick and frame made of stainless steel and the gate-plate of chromium-plated brass.

LOW-COST GENERAL-PURPOSE GEIGER COUNTER

Stated to be the first Geiger counter designed and produced as a low-cost general-purpose detector of gamma, hard beta, and X-radiation, the new " Utility " Geiger counter announced by Radiation Monitors Limited, of London, W.1, is a self-contained, lightweight, portable instrument employing the latest type of highly sensitive low-voltage halogen-quenched tube. The counter provides three ranges of visual response by flashing neon, together with a loudspeaker count of each single ionizing event at low radiation levels, thus providing an immediate appreciation of any significant flux change. As a guide to sensitivity, it may be noted that typical background counts over chalk areas are 40 to 50 per minute, while, over West of England granite, away from metalliferous areas, counts range from 110 to 180 per minute, depending on locality.

High-tension power, which is never switched off, is derived from a pack of 30-V batteries assembled in the plastic case, which is moulded from high-impact polystyrene. The current consumption under normal conditions is so low (about 1 microampere) that the batteries will normally exceed their declared shelf life. Thumb-operated controls permit single-handed operation on the medium and low ranges, but an extra-long shoulder strap is provided for convenience when surveying or prospecting for thorium or uranium ores. A pulse output socket permits muting the internal speaker and substituting a miniature crystal earpiece, or connecting to an oscilloscope or recording scaler.

With a basic price of only £10, the instrument, which measures 9 × 6 × 3 in. and weighs 3 lb, is manufactured under licence from the United Kingdom Atomic Energy Authority and employs a patented circuit evolved at the British Atomic Weapons Research Establishment.

Cutting Tools with Helical Carbide Teeth

(*Concluded from page 150*)

have a right-hand helix of between 25 and 50 deg., and their life, compared with straight-tooth cutters, is considerably greater. They have a high productivity and can be used for the machining not only of flat surfaces but also of right-angle profiles. As an example of the kind of performance that can be expected with milling cutters with helical carbide teeth of the strip type, cutting speeds and feeds, when machining a carbon steel, range from 50 to 230 m/min and 100 to 850 mm/min respectively for cutters of 10 to 20 mm in diameter, up to 80 to 500 m/min and 300 to 3000 mm/min for cutters of 60 to 150 mm diameter. For the small crown type of cutter with a large number of teeth, aleardy mentioned, these values are respectively 65 to 225 m/min and 200 to 1200 mm/min for cutters from 10 to 25 mm in diameter.

Tests on the effect on tool life of feed per tooth have shown that, with cylindrical milling cutters used for machining steel, the optimum feed per tooth is between 0·1 and 0·2 mm. With these feeds, the productivity of the tool, expressed in terms of the total length of cut made by the tool between regrinds, increases, despite the decrease in tool life which in this case accompanies the increase of the feed per tooth. These observations are made on the basis of tests carried out on a 0·45% carbon steel, using a cylindrical milling cutter of 110 mm diameter and 48 mm width, fitted with helical carbide strips with a helix angle of 27 deg., and using a cutting speed of 328 m/min and depth of cut of 2 mm.

It should be noted that the application of helical carbide teeth to these cutters, and also to reamers, twist-drills, etc., may make it necessary to modify many machine tools, especially insofar as an increase in their rotational speed is concerned.

for as little as £70

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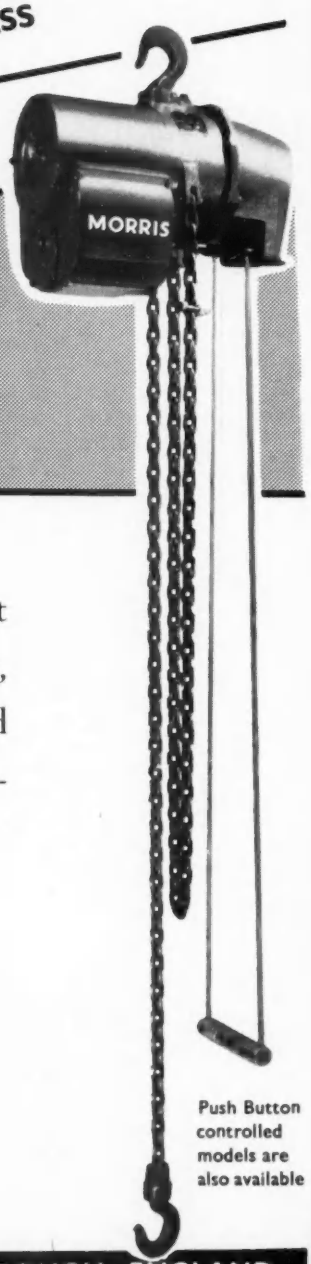

A faithful and tireless servant, it works unlimited hours without pay, costs next to nothing to run and saves time and energy for the benefit of all.

SEND FOR SECTION 80/28 (¼—1 ton sizes) AND LEARN MORE ABOUT THIS ANSWER TO A THOUSAND AND ONE HANDLING PROBLEMS. **SECTION 74/28** DESCRIBES THE 2 TON SIZE.

Push Button controlled models are also available

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NEWS OF THE MONTH

PERSONAL

Mr. H. S. Butt, O.B.E., has been appointed to the board of Dowty Equipment Limited as production director.

Mr. Hector McNeil, B.E., M.I.Mech.E., M.I.E.E., F.Inst.F., has been appointed managing director of Babcock & Wilcox Limited in succession to **Sir Kenneth Hague, M.I.Mech.E., M.I.E.E.,** who has expressed the wish to relinquish this position, which he held since January 1945.

Mr. B. McMahon, M.I.P.E., has retired from the board of Hepworth & Grandage Ltd. after 24 years service with the company.

Mr. H. P. Lord, A.F.C., B.Sc. (Eng.), A.M.C.T., has been appointed general sales manager of Sigmund Pumps Limited as from March 1, 1958.

Mr. Monty Pritchard, M.C., deputy managing director of F. Perkins Limited, has been appointed joint managing director with **Mr. F. Perkins,** who now becomes chairman and joint managing director. It is also announced that **Mr. George P. Ritchie** has joined the board of the company.

The retirement is announced of **Mr. W. H. Grinsted, O.B.E., F.C.G.I., M.I.E.E.,** director of engineering of Siemens Edison Swan Ltd.

Mr. F. H. Lawder, chief labour superintendent of the United Steel Companies, Limited, has been elected president of the Iron and Steel Trades Employers' Association. He succeeds **Mr. W. F. Gilbertson,** of Richard Thomas and Baldwins, Limited.

British Insulated Callender's Cables Limited announce the appointment of **Mr. T. P. Rome, D.F.H., A.M.I.E.E.** to the position of Liverpool branch manager, in succession to **Mr. L. J. Fairhurst,** who has retired.

George Ellison Limited announce the appointment of **Mr. B. J. Hersey** as technical engineer responsible for the sales and consultative service for Ellison hydraulic valves in the South of England and in South Wales.

Mr. Arthur Booth has been appointed director and general manager of Landmaster Limited, a member of the Firth Cleveland group.

Mr. E. T. R. Ball, A.M.I.E.E., has been appointed managing director of The British Electric Transformer Co. Ltd.

Mr. L. W. English, technical manager of Auto-Klean Strainers Limited, has been appointed a director of the company.

Mr. F. P. Liebert, B.Sc. (Tech.), A.M.I.Prod.E., has been appointed works manager of The English Electric Company's Rugby and Whetstone (Leicester) establishment, responsible to the general manager, **Mr. E. M. Price.**

Mr. A. W. Page has been appointed sales manager of Igranic Electric Co. Ltd., in succession to **Mr. R. L. Paice,** who, as a director of the company, will carry out special assignments of the board.

Mr. G. L. Brownson, B.Sc.Tech., M.I.E.E., has been appointed technical director and chief engineer of Small Electric Motors Ltd., of Beckenham. Mr. Brownson, who was works manager, is succeeded by **Mr. J. A. Wilson, B.Sc.Tech.(Hons.), A.M.I.E.E.,** formerly assistant works manager. **Mr. K. H. Harding,** sales manager of the company, has been appointed sales director.

BUSINESS NOTES

With immediate effect, the name of **Hartcliffe, Lee & Malkin Ltd.,** manufacturers of steel chains for drives, conveyors, and elevators, has been changed to **Hartcliffe Chains Ltd.,** a division of **Borg-Warner Ltd.** The address of the company remains at Steel Chain Works, St. Simon Street, Salford 3, Manchester.

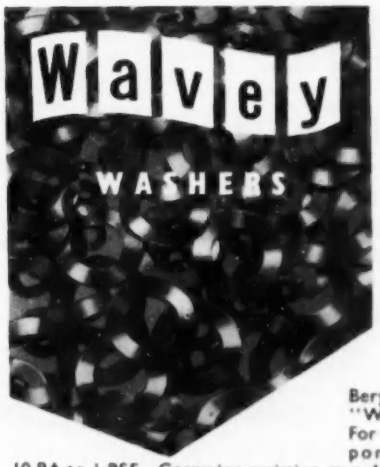
Enfield Cables Limited announce the signing of an agreement with Federal Wire and Cables Division, **H. K. Porter Company (Canada) Limited,** who will market Enfield products in Canada.

International Combustion Limited and **International Combustion (Products) Limited** have opened a new office at 22 St. Mary Street, Cardiff, with Mr. R. W. Allison in charge.

BTR Industries Ltd. have concluded a licensing agreement with **Tube Turns Plastics Inc.,** of Louisville, Kentucky, U.S.A., for the manufacture in Great Britain of unplasticized polyvinyl chloride pipe fittings, valves, and specially moulded parts by the Hendry process.

Clarkson (Engineers) Limited announce that their Canadian subsidiary, **Clarkson Engineering (Canada) Limited,** have now moved to new premises in Toronto, at 767 Warden Avenue, Scarborough.

The Chamberlain Group of Companies, with headquarters at 3 Buckingham Palace Gardens, London,



Beryllium Copper "Wavey" Washers. For Electronic Components. Range 10 BA to ¼ BSF. Corrosion resisting, non-damaging to components, higher resistance of "set", higher recovery of load, permanent spring action. They are fabricated from Beryllium copper, heat treated to VPN 350 minimum, Electro Plated to DTD.924, Cadmium Plated to DTD.904 and Passivated to DTD.923. Samples and price lists on request.

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SHEFFIELD ENGLAND

DORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

S.W.1, reports that the plant sale and hire activities of **Chamberlain Industries Limited,** Staffa Works, Staffa Road, London, E.10, will be transferred to **Chamberlain Plant Limited,** a new company with offices and works at Crown Works, Southbury Road, Enfield, Middlesex.

The General Electric Co. Ltd. announces that the British Standards Institution has granted a licence for the B.S.I. "kite mark" to be used on G.E.C. fluorescent control gear, which complies with all the requirements of the recently established B.S.2818.

English Clock Systems and **Smiths Industrial Instrument Division** (both members of the **Smiths Group of Companies**) announce the opening of combined showroom and offices at 184 Corporation St., Birmingham 4. (Telephone : Central 8737).

Simms Motor Units Ltd. have recently concluded arrangements for further representation in Sweden with **Electro Diesels** of Kiruna for servicing their fuel-injection and electrical equipment in the northern territory. Arrangements have also been made for additional service representation in Malmo, for covering, the south and south-west territory, including Stockholm, and in Uppsala, for covering central Sweden.

The trade mark " Fircleve " has been accepted by the Registrar of Trade Marks as applicable to the range of cold-rolled steel strip and flattened wire, and cold-rolled hardened and tempered steel strip and flattened wire, produced and marketed by **Firth Steel Strip Ltd.**

A new company, **Cawkell Research & Electronics, Ltd.,** of 6-8 Victory Arcade, Broadway, Southall, Middx., has been formed to extend the activities of the former **A. E. Cawkell, Electronic Engineers.** The directors of the new company are Mr. A. E. Cawkell (managing) and Mr. J. Rotheroe. The company will shortly be moving to new premises.

CONTRACTS

Rustyfa Ltd., the British consortium company founded last summer for the purpose of supplying the plant and equipment for an immense tyre factory to be built in the Ukraine, has been awarded further contracts from Russia valued at more than £5 million. These latest contracts, together with those announced last September, bring the total of Rustyfa's contribution to Britain's export drive up to £12½ million, and there is every hope that still further contracts will be negotiated in the not too distant future.

The latest group of orders placed cover pneumatic handling and weighing equipment, impregnation plant, rubber processing plant and associated electric motors, tyre testing equipment, electrical distribution substation equipment, and control panels.

A contract has just been placed by the Ministry of Supply with **Folland Aircraft Limited** for the manufacture of a development batch of 14 Folland Gnat two-seater transonic trainer aircraft for the Royal Air Force. This follows the receipt, last August, of instructions from the Ministry to proceed with preliminary work on the trainer project. Work on this aircraft was started as a private venture in 1956 and official interest soon developed thereafter. The Gnat Trainer will bridge the gap in the Royal Air Force between the primary trainer and advanced operational aircraft. It will enable pupil pilots to obtain valuable experience on transonic swept-wing aircraft at a considerably lower cost than is at present possible.

Richardsons Westgarth (Hartlepool) Ltd. have received notification from the Central Electricity Generating Board that an order is to be placed with them for the construction, erection, and commissioning of two 120-MW reheat steam turbo-alternator sets, this order having a value of more than £1¾ million.

The General Electric Co. Ltd. has received an order for the traction equipment for three new four-coach trains and four additional trailer coaches which are to be built in Portugal for the Estoril Railway. This is the third order placed with the company for the equipment of rolling stock on the line connecting Lisbon with Estoril and Cascais, and was secured in the face of the keenest competition from Continental manufacturers. Together with the rolling stock, mixed-traffic locomotive, and equipment for two traction substations supplied since 1950, the total value of contracts undertaken in connection with the Estoril Railway now amounts to some £750,000.

Metropolitan-Vickers Electrical Co., Ltd. has been awarded a contract valued at approximately £1½ million, covering the construction and equipment of the Gach Saran power system for the **Iranian Oil Exploration and Producing Company.** The scheme will comprise a 12-MW power station, switchgear, transformers, and transmission lines in the Gach Saran oilfield, located some 2500 ft above sea level in Southern Iran, whence oil will be piped to a new sea terminal at Kharg Island in the Persian Gulf. Sub-contractors for the associated civil-engineering work are **Richard Costain Ltd.,** and for the transmission lines and cable work **British Insulated Callender's Construction Co. Ltd.** The consulting engineers are **Ewbank & Partners Ltd.** The complete system is to be commissioned in May 1960.

British European Airways have placed a further order with **Heenan & Froude Limited,** of Worcester, for a complete dynamometer plant for testing engines at London Airport. The new plant will be used initially for the post-overhaul testing of Rolls-Royce Dart turbo-prop engines. With a view to possible future requirements, the capacity of the plant will be 6000 bhp.

A big order to supply 3050 diesel engines to Yugoslavia has been obtained by **F. Perkins Ltd.,** the Peterborough diesel engine company. Deliveries will be completed by the end of the year.

F. Perkins Ltd. has obtained orders totalling about £2½ million from Yugoslavia since the Yugoslavs decided to standardize on Perkins engines in 1955. It is estimated that there are now nearly 12,000 of these engines operating in Yugoslavia in tractors, combine harvesters, and lorries.

The Head Wrightson Machine Company Limited have just received confirmation that they are to receive an order from the **South African Iron & Steel Corporation,** Pretoria, valued at over £220,000, to cover the supply of a line of equipment for the cutting up of a coil of steel strip, $\frac{5}{16}$ in. thick and 54 in. wide, into sheets between 4 ft and 20 ft long.

This line of equipment is generally similar to a number of lines which The Head Wrightson Machine Company are currently building for the steel-strip industry of Great Britain, and includes a number of special features, which have been developed to overcome some of the problems associated with the handling of these heavy sheets at high speeds.

A contract, worth £55,000, for installing improved floodlighting of the Niagara Falls has been awarded to a Canadian associate of **The General Electric Co. Ltd.,** for whom **Savage & Parsons Ltd.** have designed and manufactured the special floodlighting units. The installation comprises 20 Savage HI floodlights, each of 210-million beam candlepower, fitted with detachable, automatic, remote-controlled colour-changing units, built by **Tooltech Ltd.** The new installation will replace 24 existing lamps with manual colour-control equipment, and will give eighteen times more illumination generally, using existing power supplies which could not be increased. The cost of each of these new units is £1355.

AHEAD
yesterday,
today
—and tomorrow

The upper picture shows a nineteenth century steam engine alternator built more than fifty years ago by Willans and Robinson Limited, now incorporated in 'ENGLISH ELECTRIC'. Below it is an artist's impression of the world's largest atomic power station, to be built by the ENGLISH ELECTRIC, BABCOCK & WILCOX, TAYLOR WOODROW Group at Hinkley Point, Somerset.

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in The ENGLISH ELECTRIC Group

P71A.C9

STUDY OF THE NETWORK OF EUROPEAN TRADE

The Network of Intra-European Trade, published by the O.E.E.C., 2 rue André-Pascal, Paris XVIe., is a basic document for studying the free-trade area and the common-market proposals. It is essentially composed of data, giving details, product by product, of the existing market between European countries in 1956. The main tables, covering 207 commodities and categories of commodities, are presented in matrix form, so that trade between any two of the individual O.E.E.C. countries or between any one of these countries and the proposed free-trade or common-market areas may be found immediately. Both values and quantities are given. Preliminary tables show the importance of intra-European trade within the world trade of each country or area concerned.

For the first time, statistical information, which up to the present has been scattered and incomplete, has been put together in a form allowing international comparisons to be made without difficulty.

THE ILLUMINATING ENGINEERING SOCIETY

The summer meeting of **The Illuminating Engineering Society,** of 32 Victoria Street, London, S.W.1, will take place at Eastbourne from May 11 to 14, 1958. In addition to a display of lighting equipment, the provisional programme will include the following papers :—

" Lighting trends since 1954 ; a survey of commercial, industrial, and display lighting ", by H. H.. Ballin ; " The design and production of glassware for lighting ", by D. Shellshear and C. D. Cartwright ; " Lighting in Finland ", by E. Paivarinne ; " Lighting at the Brussels International Exhibition ", by Andre Boereboom ; " Lighting and Architecture ", by G. Grenfell Baines and A. L. Hogg ; and " Character and compromise in hotel lighting", by W. R. Stevens and C. Dykes Brown.

MOBILE UNIT FOR DEMONSTRATION OF DIAMOND-IMPREGNATED TOOLS

A mobile demonstration van has recently been put on the road by **Impregnated Diamond Products Ltd.,** of Gloucester, to demonstrate their Neven diamond-impregnated tools for various industries. Housed in the body of the van are eight different machines for providing practical illustrations of the cutting and grinding of tungsten carbide, glass, ceramics, quartz, germanium, etc. The unit is completely self-contained and will be travelling through industrial areas in the U.K. during this year.

PRODUCTIVITY SERVICE IN HOT-DIP GALVANIZING

Since 1954, when the activities and technical work of the **Hot Dip Galvanizers Association,** of 34 Berkeley Square, London, W.1, were extended to include a productivity service for its members, this service has been of definite usefulness and practical value in carrying out work-study investigations in members' firms, preparing publications on various aspects of productivity, arranging training courses and conferences, and providing films and an advisory information service.

To supplement the practical work, a series of manuals on various aspects of productivity has been planned, with a view to providing members with a permanent guide to increasing efficiency. The first of these, " Productivity in Hot Dip Galvanizing—A Study Made in the U.S.A." has already proved very successful. The latest publications in this field are " General Galvanizing—A Manual of Good Practice " and " General Galvanizing—A Manual of Costing Practice ". The first of these outlines the best possible technical and practical methods for achieving good galvanized coatings and has been prepared particularly for the use of shop-floor supervisors and leading hands ; the second focuses attention on the importance of cost-finding in increasingly competitive conditions. Both of these publications are well up to the standard of excellence set by their predecessor. A third book, " General Galvanizing—A Manual of Good Housekeeping and Safety " is in an advanced stage of preparation, and two further manuals, entitled " Materials Handling in the Galvanizing Industry " and " Work Study in the Galvanizing Industry ", are planned for future publication.

In addition, the film of " Work Study—Its Application to Teamwork ", showing how special work-study techniques can improve team-work and complex operations, has been very well received, and prints have been purchased by educational and industrial companies in the U.K. and by galvanizers in Australia, Canada, and Japan. Black-and-white copies (16-mm or 35-mm) of this film (running time, about 20 min) are available on loan from the **Zinc Development Association,** 34 Berkeley Square, London, W.1, or from the **Central Film Library,** Government Building, Bromyard Avenue, Acton, London, W.3.

CONFERENCES ON ELECTRONIC DIGITAL COMPUTERS

In view of the established usage of electronic computers to scientific computation and their potentialities for accountancy and other commercial procedures, the **Birmingham College of Technology** is organizing a series of one-day conferences on electronic digital computers and their industrial applications. The first of this series, with special reference to Ferranti computers, was held at the College at Gosta Green, on Wednesday, March 26, 1958.

The speakers at the conference were as follows :—Mr. M. Jackson, M.Sc., of the College of Technology (" A Survey of the Components of a Computer and their Function ") ; Mr. W. F. M. Payne, B.A., of Ferranti Limited (" The Philosophy of Ferranti Computing Systems for Commercial, Industrial, and Scientific Work ");

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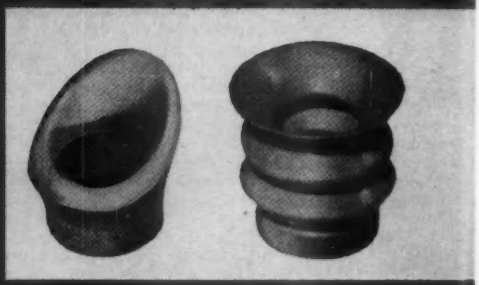
Aircraft sextants and periscopes must operate perfectly at the low temperatures encountered in high-altitude flights. So even the flexible eyepieces of these instruments present a problem—for natural rubber becomes too rigid under these conditions. I.C.I. Silicone Rubbers, however, retain their flexibility—and many other desirable properties—over a very wide temperature range. In this case they completely met the requirement for operation at −40°C. And they will meet other specifications, too, from 250°C to −80°C. If you have a problem within this range—electrical, chemical or mechanical—I.C.I. Silicone Rubbers are certainly worth looking into.



Periscopic instruments for aircraft, manufactured by Kelvin and Hughes Ltd., with eyepieces of I.C.I. Silicone Rubber moulded by Waltham Rubber and Plastics Ltd.

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Mr. F. Keay, M.A., A.C.I.S., of Ferranti Limited (" Commercial and Industrial Applications, with Special Reference to Stock Recording, Material Control, and Production Planning ") ; and Dr. C. M. Wilson, B.Sc., Ph.D., of Ferranti Limited (" Mathematical and Scientific Work on Computers, in the Fields of Research, Engineering, and Design ").

NEW PRESS AND FABRICATING DEPARTMENT FOR THE CARRON COMPANY

As the Glasgow works of the Carron Company were unable to cope with existing requirements and demands, they have been closed down, and all sheet-metal press and fabricating work has been transferred to a new 30,000-sq. ft department at their works in Falkirk, Stirlingshire.

The new department, which was opened on March 1, 1958, has been designed to cater for the urgent need for additional accommodation and more and heavier machines. Included in the equipment are power presses with capacities up to 100 tons, and pressings of many kinds are being made within this range. In addition, facilities are provided for an extensive range of mild-steel plate fabrication up to 1¼ in. in thickness, using up-to-date electric-arc welding and ancillary plant with fully trained operators.

LEIPZIG SPRING TRADE FAIR

Mr. A. J. Cox, General Manager of the Birmingham Exchange and Engineering Centre, attended this year's Leipzig Spring Trade Fair at the invitation of the Foreign Chamber of Trade. In a report he writes :—

" This year there were 9600 exhibitors, representing 43 different countries, at the Fair. Of the 2900 foreign exhibitors, nearly half were from Western Germany, and the number of exhibitors from the free world showed an increase of 20% over 1957. The organization of the Fair was specially designed to cater for the needs of overseas visitors, and daily reports were issued in four languages.

" The general technical standard of engineering goods from all the Iron Curtain countries appeared to be good, although the finish of the Chinese products was not of a very high standard. Machine tools from the U.S.S.R. and Eastern Germany were very much in evidence, their design and finish being excellent.

" British exhibits at the Fair were scarce. Britain, in common with some other western countries, does not officially recognize the existence of the German Democratic Republic. In consequence, she has no trading agreement and export licences are difficult to obtain. Although East Germany is anxious to start bilateral trade with the U.K., this type of trade is not really suitable, since many of the products which East Germany would want to export are also made in the U.K. "

CLEAN-AIR CONFERENCE REPORT

The first publication of the National Society for Clean Air—formerly the National Smoke Abatement Society—is the *Proceedings* of the Conference held at Hastings in October last, available from the Society, at Palace Chambers, Bridge Street, London, S.W.1, price 12*s*. 6*d*. The volume contains all the papers, lectures, and addresses, together with the discussions, on widely differing aspects of the air-pollution problem.

The Des Voeux Lecture on " Meteorology and Air Pollution ", by the Director-General of the Meteorological Office, Sir Graham Sutton, is an important contribution which will be of interest to all concerned with the erection of new buildings. From the viewpoint of fuel policy, an address by the Minister of Power, Lord Mills, is particularly interesting. Two papers discuss the question of air pollution from road vehicles, two more the administrative problems of the Clean-Air Act, and others examine the Act from the standpoint of industry and fuel efficiency. The Society's President, Dr. R. Lessing, devotes most of his Presidential Address to a thoughtful discussion of the means for controlling the primary sources of pollution. There is also a short report on the availability of smokeless fuels and a resolution and statement calling for greater efforts to organize the training and certification of boiler operators.

BRITISH RUBBER DIRECTORY

The 1958 edition of the *Directory of British Rubber Manufacturers and Products*, published by the Federation of British Rubber and Allied Manufacturers, provides a complete buyer's guide to the British Rubber Industry in English, French, German, and Spanish.

Over 600 products are listed under headings which cover belting, hose, engineering components, domestic, sports, and surgical goods, adhesives, insulating materials for heat and sound, proofed fabrics, floor coverings, soles, heels, footwear, plastic, and latex foam. There is also a complete section devoted to tyre manufacturers.

The directory is primarily designed for overseas circulation. Of an initial printing order of 4000, about 3500 will be sent abroad. However, a limited number will be available on application to the Federation offices at 43 Bedford Square, London, W.C.1., at 28*s*. post free.

" DESIGN REVIEW " BECOMES " DESIGN INDEX "

The Council of Industrial Design announces a change of name for *Design Review*, its photographic and sample catalogue of well-designed consumer goods. From April 1, *Design Review* will be known as *Design Index*, which name, it is felt, conveys more clearly the nature of the service offered, i.e., a permanent reference which manufacturers, trade buyers, retailers, and the general public can use as a source of information and ideas on new and well-designed household goods on the market. It should also remove the idea that the index is a publication. Besides its immediate service as a guide to products, *Design Index* forms the basis of selection of goods to be shown in The Design Centre, of which it now forms an integral part.

The Specialist Foundry
with own machine shop
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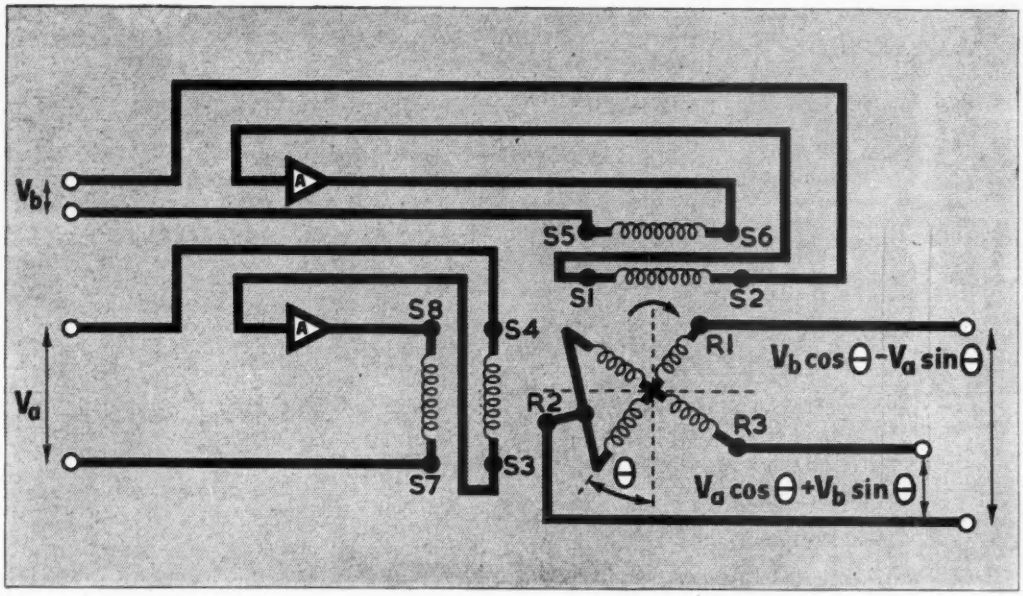
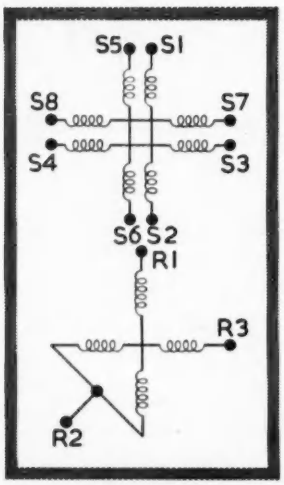


Synchro Feedback Resolver

15RSF4SL



This Resolver is used in Analogue Computers to multiply the analogue signal by the sine or cosine of the angle set in on the rotor shaft.

A feedback amplifier is employed in both stator windings to reduce the variation of transformation ratio with signal level. By this means the accuracy is improved by a factor of at least 2, compared with the accuracy when no feedback amplifiers are employed, and phase shift is reduced to negligible proportions.

The Sperry Synchro Feedback Resolver is British-designed and manufactured with British materials throughout, and it is available *now*. Send for technical data sheet.

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BRITISH STANDARDS

(Copies of British Standards may be obtained from the British Standards Institution, 2 Park Street, London, W.1)

Diamond Dies for Wire Drawing (B.S. 2946 : 1958).

This revised British Standard (price 4*s*.) now includes requirements for both reinforced and non-reinforced dies, and therefore supersedes the existing standards (B.S. 1393 and 1168) for these products.

The specification contains clauses on quality of die stones, bore of dies, mounting, casing, size, assembly of dies, and marking. One of four appendices contains a useful *aide-mémoire* for purchasers, in the form of a summary of the information recommended to be supplied with an enquiry or order.

Voltages for A.C. Transmission and Distribution Systems (B.S. 77 : 1958).

This further revision of the old-established B.S. 77 has been published mainly because of the changes in the organization of the electricity supply industry in the United Kingdom since the last edition appeared ; the scope of the standard has been extended to cover industrial systems as well as public supply systems.

The new edition (price 3*s*.) is in close agreement with Publication 38 of the International Electrotechnical Commission, particularly as regards the upper voltage limit associated with each system voltage, upon which the design of much electrical equipment depends.

Only 415/240 V is now recognized as standard for 3-phase 4-wire distribution systems. The number of standard voltages above 1000 V has been reduced, but 330 kV and 380 kV have been added to the list. Preferred voltages for new installations are clearly indicated.

Pipe Threads (B.S. 21 : 1957).

This long-established British Standard, last revised in 1938, formerly specified only fundamental definitions and basic sizes of threads and the permissible tolerances. These have been reproduced unaltered in the present edition ; however, the text has been revised and extended to include illustrations and recommendations for gauging pipe threads, and tolerances for reference gauges. Two kinds of pipe thread are dealt with :—

Jointing Threads. These are for joints made pressure-tight by the mating of the threads ; they include taper external threads for assembly with either taper or parallel internal threads.

Longscrew Threads. These are parallel external pipe threads used for longscrews (connectors) where a pressure-tight joint is achieved by the compression of a soft material onto the surface of the external thread by tightening a back nut against a socket.

The BSP size range is from $\frac{1}{8}$ in. to 6 in. nominal bore inclusive, and the standard (price 7*s*. 6*d*.) gives details of thread forms, dimensions, and tolerances, together with the method of designating each type of thread.

Classified Advertisements

The rate for all classified advertisements is 9d. per word : in bold print 1s. per word : minimum order 10s. Box-number advertisements 1s. extra. Instructions, together with remittance, must be received not later than the 1st of each month for advertisements to appear in the same month's issue.

PUBLIC NOTICES AND APPOINTMENTS

WILMOT BREEDEN FELLOWSHIP

Applications are invited for a Fellowship to be held in association with the College of Technology, Birmingham. The value of the Fellowship, which is for a two-year term, is £1,000 per annum.

A candidate for the Fellowship should normally have had two or three years research or industrial experience. He must be acceptable to the College of Technology, Birmingham, as a post-graduate student and should have an Honours Degree at a University in the British Commonwealth or an equivalent qualification.

The Wilmot Breeden Fellow will engage in an enterprise of such a character as to require the facilities both of the College and of the Company, and his time will be divided between the two. The activities with which the Company is especially concerned include Mechanisms, Electro-Chemistry, Metal Finishing, Metallurgy, Metal Formation, Hydraulics, Electronics.

Full details may be obtained on application to the Secretary, Wilmot Breeden Limited, Amington Road, Birmingham 25.

Final applications must be received by the Secretary before 1st May, 1958.

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Heavy Engineering Firm in the South of England requires the services of an Experienced Stress Analyst who should be thoroughly familiar with strain-gauge testing techniques, and have actual experience of the handling of such auxiliary equipment as multi-channel recorders, cathode-ray oscilloscopes, etc.

The successful applicant should have specialized in stress analysis work, i.e. an Engineer is required who has the necessary theoretical background coupled with actual field experience.

The Applicant would from time to time be required to travel in England and abroad for short periods, in order to carry out tests in new and existing plants which the company has installed.

The post, which offers extremely interesting work on a variety of problems in many fields, would be considered a permanent one.

Selected applicants will be invited for an interview when such questions as salary (which will be an appropriate one for the man with the right experience), pension scheme, and housing will also be discussed.

Applicants are invited to submit a description of their experience and qualifications to Box No. L. E. 458.

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NEW TECHNICAL BOOKS

Hydro-Electric Engineering Practice. Edited by J. Guthrie Brown, M.Inst.C.E., Pres.Inst.Struct.Eng. (1956/57), M.I.E.Aust., M.N.Z.I.E., M.Soc.C.E.(France). In three volumes. Publishers : Blackie & Son Limited, 16/18, William IV Street, London, W.C.2. *Vol. 1* = 1220 pp., 720 illustrations, price 189/–. *Vol. 2* = 770 pp., 360 illustrations, price 126/–. *Vol. 3* = 500 pages, 120 illustrations, price 84/–.

Brilliantly conceived and produced, these three volumes are the work of a group of engineers who are actively engaged in hydro-electric engineering. By virtue of the wide scope of the subject and the intensive coverage provided, three separate volumes have been published, each a complete work in itself. Thus, Vol. 1 deals with the civil-engineering aspects of the subject, Vol. 2 with mechanical and electrical engineering, and Vol. 3 with economics, operation, and maintenance.

Beautifully printed and illustrated, these excellent books constitute truly authoritative works on modern British and Continental hydro-electric design, construction, operation, and maintenance, and include the latest methods adopted in Great Britain, on the Continent, and elsewhere. As such, there can be no doubt that they will be of inestimable value not only to practising engineers but also to advanced students.

The BEAMA Catalogue. Fourth Edition. 962 pages. Published for The British Electrical & Allied Manufacturers' Association (Incorporated) by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price : 120/–.

Serving as a comprehensive buyers' guide throughout the world to the products and services of the British electrical industry, this fourth edition of The BEAMA Catalogue contains over 690 pages of profusely illustrated announcements displaying the products manufactured by member firms, conveniently classified in distinctive colours into various divisions, i.e., electrical power plant ; electrical equipment in industry, transport, and communications ; and domestic and commercial electrical appliances, lighting, accessories, and installation material. In addition, separate supplementary volumes of these divisions, including the complete trade-directory of all member firms, have been made available for special use at the Brussels Exhibition. The trade-directory gives the principal addresses of all BEAMA member firms in the U.K., subsidiary or branch offices, etc., and nearly 400 names and addresses, grouped territorially, of overseas branches, representatives, and agents.

A useful five-language glossary of technical terms is also included, with product headings listed in English, French, German, Portuguese, and Spanish, while the classified buyers' guide lists under more than 1300 headings the comprehensive range of electrical and allied equipment manufactured by BEAMA firms.

Casting in Steel. 116 pp., 149 illustrations. Published on behalf of The British Steel Founders' Association by Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price : 18/–.

Outstandingly produced and illustrated, this excellent volume describes, in broad terms, what steel castings are, how they are made, the basic principles of good design, the variety of compositions and mechanical properties which can be obtained, and the tests and inspection techniques used to ensure that the quality of steel castings does not fall short of requirements. As such, it is an invaluable source of information to potential users, designers, and engineers of the characteristics and functional attributes of cast-steel components.

In addition to a comprehensive index, the book includes a useful list of relevant British Standards and a glossary of steel-foundry terms.

Daylight Through the Mountain. Edited by Frank Norman Walker. 454 pp., 54 illustrations. Published by Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2, and distributed by Sir Isaac Pitman & Sons, Ltd., 381/3 Church Street, Toronto, Canada, for the Engineering Society of Canada. Price : 45/–.

Between 1852 and 1856, when Canada was transformed from an ox-cart economy to one of rapid transportation, powered by steam engines, there arose a select group of engineers who, by their natural ability and experience, had learned how necessary it was to ensure that railway tracks were laid perfectly. Not least among these were the Shanly brothers, Walter and Francis, whose letters and labours form the subject of this absorbing volume. Walter Shanly became, at the age of forty, general manager of the longest railway in the world (the Grand Trunk Railway of Canada, from Portland, Maine, and Quebec to Sarnia and Detroit, a total distance of nearly 1100 miles), while Francis surveyed, located, and built more miles of railway in Canada than any other engineer.

In the pages of this book, not the least fascination of which is the inclusion of numerous photographs of old documents, buildings, locomotives, and rolling-stock, the story of the almost incredible tenacity and courage of those who applied their knowledge to the preparation and assembly of materials and the execution of this heart-breaking task is unfolded. For leadership and skill in this vast performance, none ranked higher than the Shanly brothers, and in their letters they speak for themselves of their fight to bridge rivers and even to move mountains.

Telecommunication Economics. By T. J. Morgan, A.M.I.E.E. 468 pp., 112 illustrations. Publishers : Macdonald & Co. (Publishers) Ltd., 16 Maddox Street, London, W.1. Price : 50/–.

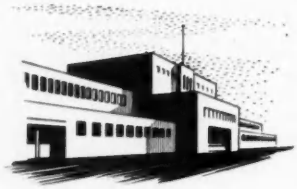
The recent availability of the first Atlantic cable for telephony emphasizes the importance of telecommunications in industrial, commercial, and human relationships. However, in any projected undertaking to-day, it is not only a question as to whether scientifically something can be done, but also, from the economical point of view, whether it is possible to afford doing it. This excellent book, the first of its kind ever to be published, investigates the economic merits of various alternative engineering schemes, particularly those arising when planning large utility undertakings. Special attention is paid to the layout of multi-exchange systems for rural areas and urban districts, and some of the difficulties involved in the economic study of replacement schemes, in cases where the plant has little or no market value, are considered. The economic routing of telephone traffic in large multi-exchange systems and between systems is also covered.

There can be no doubt that this authoritative work, though fundamentally addressed to telecommunications engineers, is also of great value to other organizations to whom the methods it suggests are also applicable.

Hydraulics and Fluid Mechanics. 10th Edition. By E. H. Lewitt, B.Sc., Ph.D., M.I.Aero.E., A.M.I.Mech.E. 746 pp., 362 illustrations. Publishers : Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price : 37/6.

This well-known text-book, which covers the syllabuses of the B.Sc.(Eng.), I.C.E., and I.Mech.E. examinations in this subject, is clearly written and comprehensive. This new edition has been completely reset and the material has been re-arranged and in places rewritten, to bring it into line with the revised examination syllabuses in Fluid Mechanics.

The work on the effects of supersonic speed has been revised and expanded into a separate chapter, and new chapters have been added on the frictional flow of gases through tapering pipes and through ducts of any cross-section. In addition, the descriptive matter and illustrations of hydraulic machinery, etc. have been replaced by views and details of modern plant and equipment.



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2. Electro-Erosion Machine for Reservicing Carbide Tools. With the electro-erosion machine for reservicing carbide tools described in a 4-page leaflet, because the process is entirely electrical, there is no physical contact between the grinding wheel (electrode) and the tool. Metal particles are removed from the tool under the influence of a controlled electrical discharge across a dielectric gap between the electrode and tool, maintained by a film of oil. The largest single economy offered by this method is the direct and immediate saving in diamond-wheel costs.

For the smaller shop, the machine offers a simplified and inexpensive method of offhand-grinding of carbide tools, without risk of damage to tools or expensive diamond wheels by operators without special knowledge of carbide-tool reservicing.

3. Wire-Grommet Safety Nets. Widely used in industry for the safety of personnel, buildings, and valuable plant, a range of wire-grommet-type safety nets is concisely described in a 2-page leaflet. These nets limit the area of fragmentation when blasting in mines and quarries, thus protecting personnel and plant from danger. They are also advantageous when carrying out running tests on new machinery. Any area of possible damage from experimental plant is thus reduced and personnel are able to observe dangerous tests in absolute safety. Another use of these nets is as a safety measure for personnel handling large stacks of material. For example, nets are frequently stretched across hoppers, the pulverized fuel passing through the net which, however, prevents personnel from falling into the hopper.

4. Self-Lubricating Bearings. A 14-page illustrated brochure gives useful data and dimensions of a range of self-lubricating bearings, including plummer blocks, flange bearing units, cartridge bearing units, take-up bearing units, and flangette bearings. They are supplied for light and medium duty and, in addition, plummer blocks for heavier duty are available.

The bearings described are self-lubricating, self-sealing, and self-aligning. They are packed with grease during manufacture, lithium grease normally being used for temperatures up to 250°F, and silicone grease for higher temperatures. Moreover, they require no attention during their lifetime and are recommended for use where dirt, dust, soil, grit, and ashes are encountered. They can also be used under wet conditions without detriment and for all types of transmission equipment, conveyors, elevators, and agricultural and textile machinery, and are completely interchangeable with their American equivalents.

5. Precision Measuring Instruments. A 32-page catalogue gives particulars of a comprehensive range of precision measuring equipment, comprising dial gauges, cylinder-bore gauges, test sets, comparators, etc. The catalogue includes details of a recently introduced comparator to deal with many measuring problems which have hitherto required the manufacture of special equipment, six typical applications being illustrated and described. Also included are particulars of a recent model of dial snap gauge.

6. Industrial Finishes. An excellently presented 40-page catalogue describes a wide range of industrial finishes aimed at minimizing the many new problems which have arisen in methods of preparation and application of paint in industry. The catalogue comprises sections dealing with the pre-treatment of metal surfaces and the application of industrial finishes by brushing, roller coating, dipping, flow coating, spraying, and stoving, supplemented by technical information on the various types of products mentioned. Details are also given of paints particularly recommended for the maintenance and decoration of factories, and a pipe identification chart is also included.

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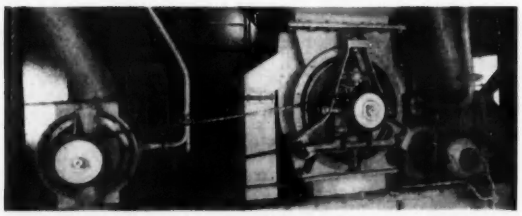

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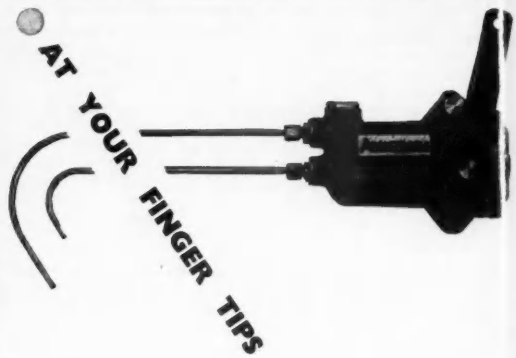

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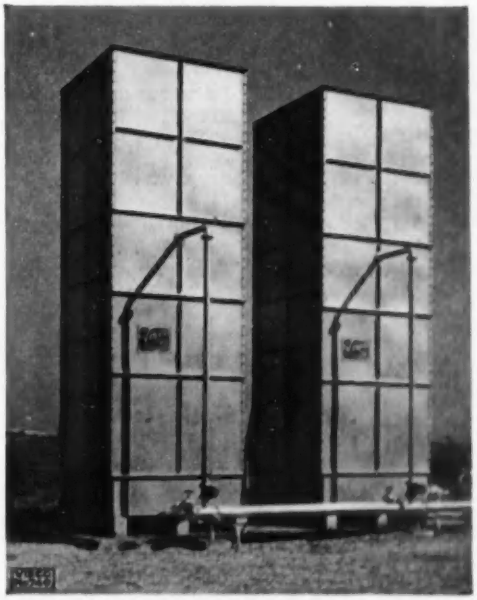

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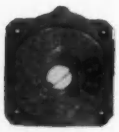

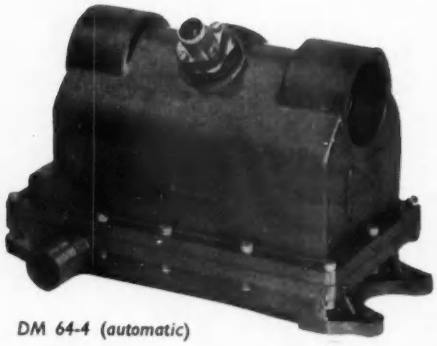

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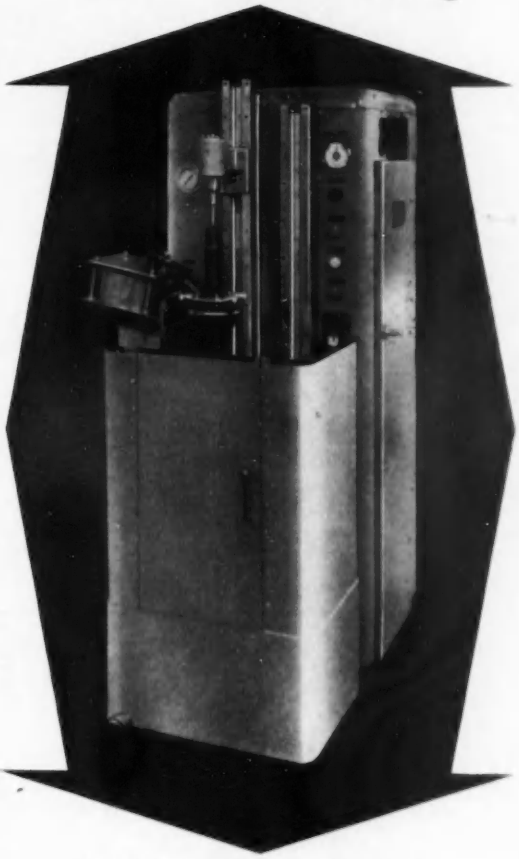

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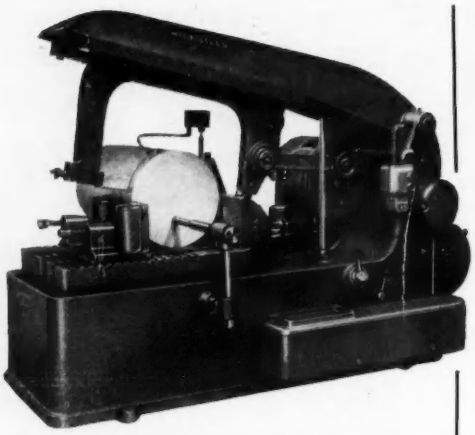

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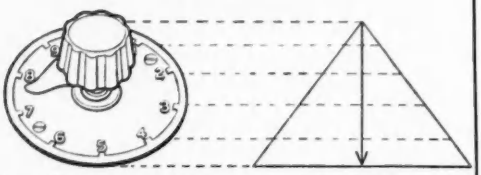

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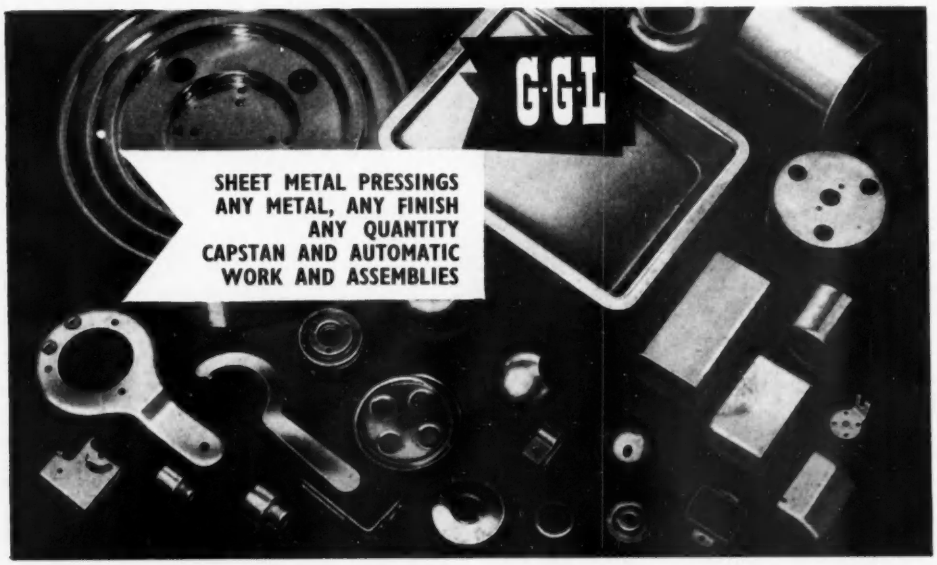

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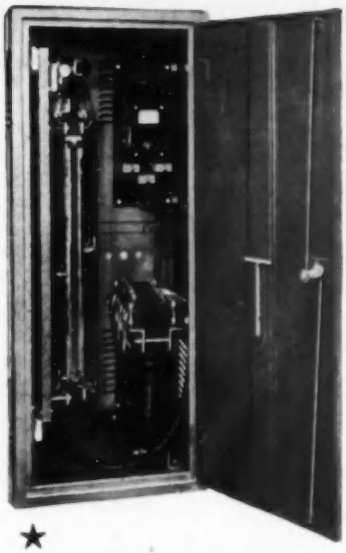

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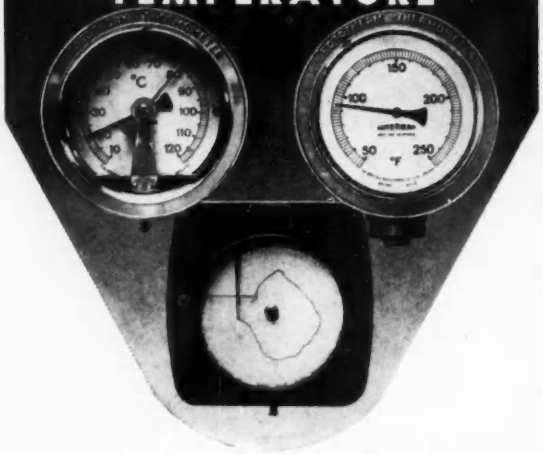

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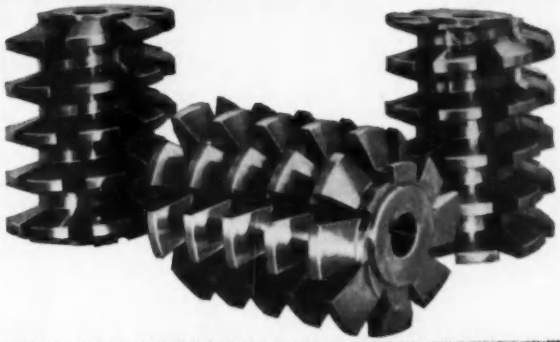

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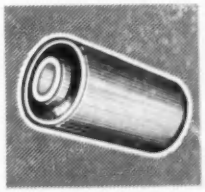

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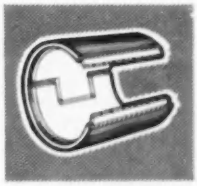

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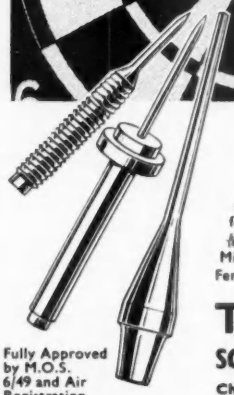

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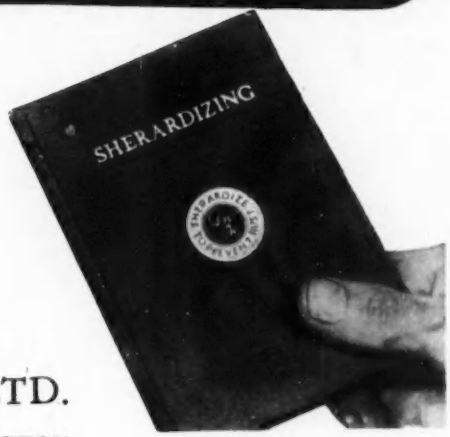

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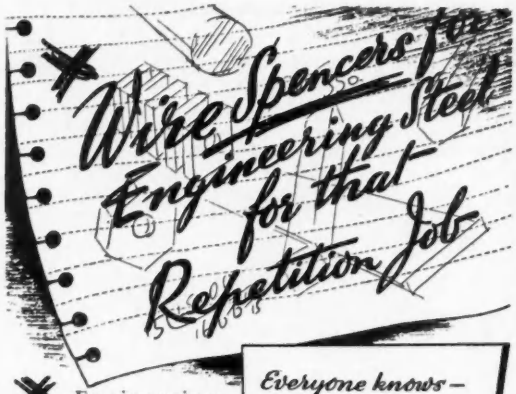

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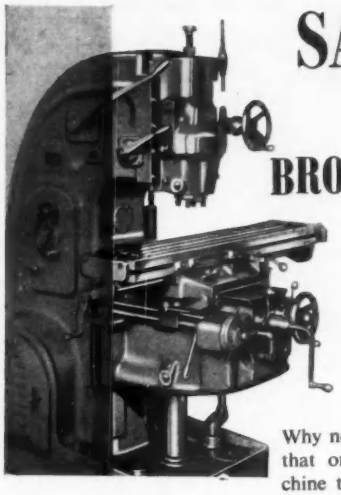

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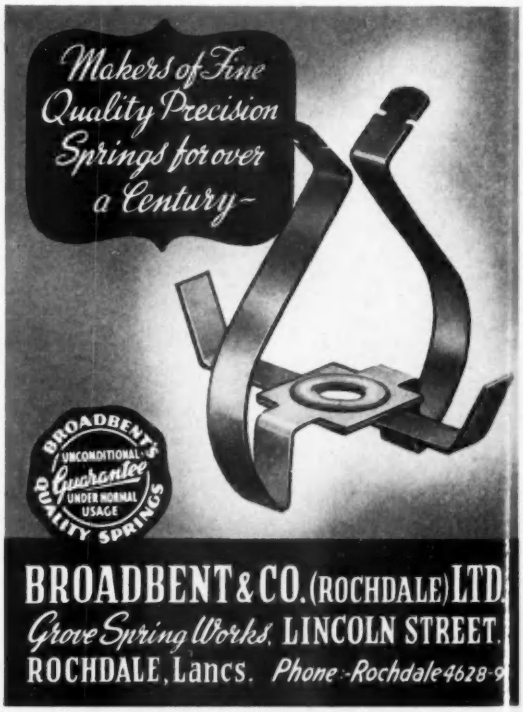

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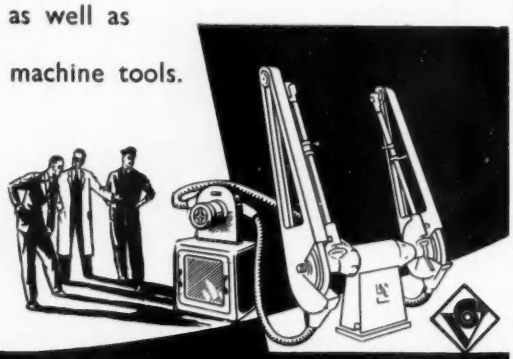

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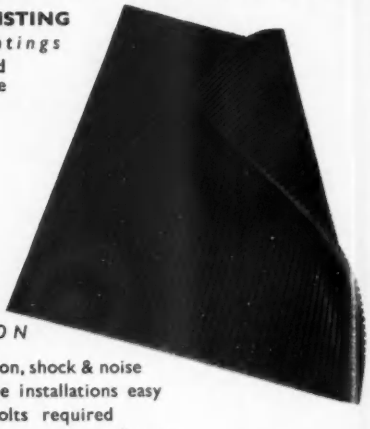

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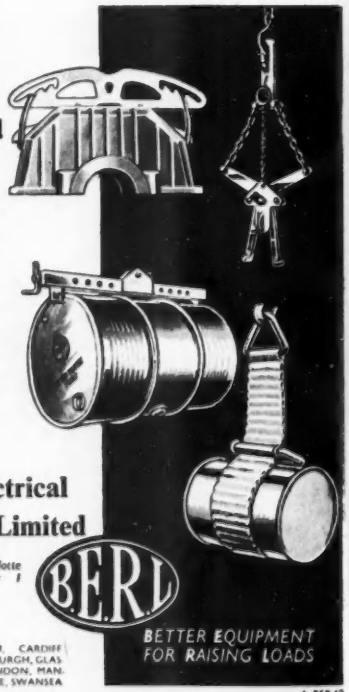

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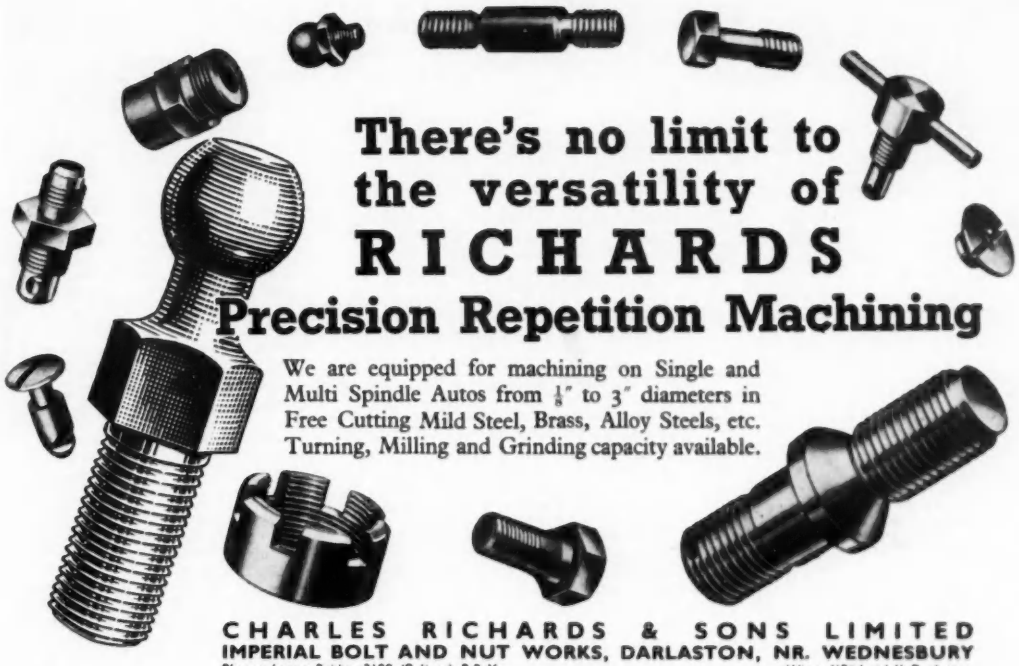

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Birfield Group ..... A69 & A70
Agency—Central News Ltd.

Borg & Beck Co. Ltd. ..... —
Agency—H. Raymond Morgan

Borg-Warner Ltd. A32
Agency—Stowe & Bowden Ltd.

Brady, G., & Co. Ltd. A59
Agency—Stowe & Bowden Ltd.

Brammer, H., & Co. Ltd. ..... —
Agency—Morison's Press (Adv.) Service Ltd.

Brayshaw Furnaces & Tools Ltd. A99
Agency—Ingham Butterworth Ltd.

British Electrical Repairs Ltd. A104
Agency—Donald Macdonald (Adv.) Ltd.

British Electrical Development Assn., The ..... —
Agency—Mather & Crowther Ltd.

British Oxygen Gases Ltd. ..... —
Agency—F. C. Pritchard Wood & Partners Ltd.

British Power Transformer Co. Ltd., The A97
Agency—Dorland Advertising Ltd.

British Rolling Mills Ltd. ..... —
Agency—Maurice G. Parker Ltd.

British Rototherm Co. Ltd., The A98
Agency—Pitchford's Advertising Ltd.

British Thomson-Houston Co. Ltd., The ..... —
Agency—Technical & General Adv. Agency Ltd.

British Timken Ltd. A81
Agency—H. Raymond Morgan

Broadbent & Co. (Rochdale) Ltd. A102
Agency—Arthur Burns Publicity

Brockhouse, J., & Co. Ltd. A102
Agency—A. N. Holden & Co. Ltd.

Brockmoor Foundry Co. Ltd., The ..... —
Agency—Willington Advertising Ltd.

Bronx Engineering Co. Ltd., The ..... —
Agency—A. N. Holden & Co. Ltd.

Brown, Boveri & Co. Ltd. A15

Brown, David, Corporation (Sales) Ltd., The ..... —
Agency—Dudley Turner & Vincent Ltd.

Burtonwood Engineering Co. Ltd. ..... —
Agency—Stowe & Bowden Ltd.

Caldwell, T., & Son ..... Cover 3

Carobronze Ltd. ..... —

Carter Gears Ltd. A10

Cashmore, John, Ltd. A94
Agency—Sandbrook, Metcalf & Co. Ltd.

Cementation (Muffelite) Ltd. A35
Agency—Napper Stinton & Woolley Ltd.

Central Tool & Equipment Co. Ltd. ..... —
Agency—Applied Designs (Advertising) Ltd.

Chapman & Hall Ltd. 173

Chatwin, Thomas, & Co. A6
Agency—A. N. Holden & Co. Ltd.

Churchill, Charles, & Co. Ltd. A68
Agency—Broadway Adv. Service Ltd.

Churchill Machine Tool Co. Ltd., The ..... —
Agency—Associated British Machine Tool Makers Ltd.

Churchill-Sturm Ltd. ..... —
Agency—Broadway Adv. Service Ltd.

Clarkson Engineers Ltd. ..... —
Agency—Ripley Preston & Co. Ltd.

Clayton-Wright, Howard, Ltd. A99
Agency—Ripley Preston & Co. Ltd.

Coin Insulation Ltd. ..... —
Agency—Havas Ltd.

Colt Ventilation Ltd. ..... —
Agency—Greenlys Ltd.

Cooper & Co. (B'ham) Ltd. ..... —
Agency—Nicholls Dorrity Advertising Ltd.

Consolidated Pneumatic Tool Co. Ltd. ..... —
Agency—Crane Publicity Ltd.

Cork Manufacturing Co. Ltd. A87
Agency—H. Raymond Morgan

Cossor Instruments Ltd. ..... —
Agency—Saward, Baker & Co. Ltd.

Coulthard, Wm., & Company Ltd. ..... —

Crofts (Engineers) Ltd. ..... —

Croda Organisation, The ..... —
Agency—Storey Evans & Co. Ltd.

Cronite Foundry Co. Ltd., The ..... —

Crossley Brothers Ltd. ..... —
Agency—Osborne-Peacock Co. Ltd.

Crowthorn Engineering Co. Ltd. A28
Agency—J. K. Clayton Advertising Ltd.

Curnon Engineering Co. ..... —
Agency—Portland Advertising Service Ltd.

De Roll, Louis, Iron Works Ltd. A65
Agency—D. H. Brocklesby Ltd.

Delapena & Son Ltd. ..... —
Agency—S. D. Toon & Heath Ltd.

Deloro Stellite Ltd. ..... —

Diamond Screw & Cotter Co. Ltd., The A100
Agency—A. N. Holden & Co. Ltd.

Dubied, Edouard, & Cie, S.A. A36

Dunlop Rubber Co. Ltd. A71
Agency—Charles F. Higham Ltd.

Eagle Pencil Co. A95
Agency—Saward Baker & Co. Ltd.

Elcontrol Ltd. ..... —
Agency—Fredk. E. Potter Ltd.

Electric Construction Co. Ltd., The ..... —

Electric Resistance Furnace Co. Ltd. A92
Agency—Nigel Rainbow & Partners Ltd.

Electrical Power Engineering Co. (B'ham) Ltd. ..... —
Agency—Nicholls, Dorrity Advertising Ltd.

Electro-Dynamic Construction Co. Ltd. ..... —
Agency—J. Peers and Associates Ltd.

Elgar Machine Tool Co. Ltd. ..... —
Agency—Howard Panton Ltd.

Elliott, E., Ltd. ..... —
Agency—Sterling Advertising Ltd.

Ellison, George, Ltd. A11
Agency—Crossley & Co. Ltd.

English Electric Co. Ltd., The A84
Agency—Technical Adv. Service

English Glass Co. Ltd., The ..... —
Agency—Frank Gayton Advertising Ltd.

English Steel Tool Corporation A20
Agency—Technical & General Adv. Agency Ltd.

ENV Engineering Co. Ltd ..... —
Agency—Allardyce Palmer Ltd.

Evertaut Ltd. ..... —
Agency—Elliott Advertising Ltd.

Fabbrica Nazionale Seghette da Metallo S.p.A. ..... —

Factory Equipment Exhibitions Ltd. ..... —
Agency—London Press Exchange Ltd.

Faure-Herman, Ets. A92

Fibreglass Ltd. ..... —
Agency—Cecil D. Notley Adv. Ltd.

Firth Brown Tools Ltd. ..... —
Agency—Stanley D. Dickson

Firth Cleveland Steel Strip Ltd. ..... —
Agency—C. R. Casson Ltd.

Firth-Derihon Stampings Ltd., The ..... —
Agency—Stanley D. Dickson

Firth, Thos., & John Brown Ltd. 17
Agency—Stanley D. Dickson

Fischer Bearings Co. Ltd. ..... —
Agency—H. Raymond Morgan

Flame Hardeners Ltd. ..... —

Flexello Castors & Wheels Ltd. 96
Agency—Dudley Turner & Vincent Ltd.

Fodens Ltd. ..... —
Agency—A. H. Knowles Ltd.

Follsain-Wycliffe Foundries, Ltd. 74

Ford Motor Co. Ltd. 33
Agency—Rumble Crowther & Nicholas Ltd.

Fordsmith, H., Ltd. ..... —
Agency—Arthur Burns Publicity

Francis, Wm. C., Ltd. 75

Fraser, Andrew, & Co. Ltd. ..... Cover 2
Agency—J. Peers and Associates Ltd.

Gas Council, The ..... —
Agency—C. P. Wakefield Ltd.

Gauge & Tool Makers' Association 74
Agency—Clifford Martin Ltd.

General Electric Co. Ltd., The A3

Gibbons Bros. Ltd. ..... —
Agency—Elliott Advertising Ltd.

Gloucester Foundry Ltd. ..... —
Agency—Print for Industry Ltd.

Goodyear Tyre & Rubber Co. (G.B.) Ltd., The A73
Agency—Erwin Wasey Ruthrauff & Ryan Ltd.

G.P.A. Tools & Gauges Ltd. A108

Griffiths, A. E. (Smethwick) Ltd. A48

Griffiths, Gilbart Lloyd & Co. Ltd. A96
Agency—Nicholls Dorrity Advertising Ltd.

Guest, Keen & Nettlefolds (Midlands) Ltd. ..... —
Agency—Cecil D. Notley Adv. Ltd.

G.W.B. Furnaces Ltd. ..... —
Agency—Crane Publicity Ltd.

Hackbridge & Hewittic Electric Co. Ltd. A53
Agency—Industrial Publicity Service Ltd.

Hallamshire Steel & File Co. Ltd., The ..... —
Agency—Downtons Ltd.

Hall, Harding Ltd. ..... —

Hallmac Tools Ltd. A44
Agency—Jack White & Associates

Hancock & Co. (Engineers) Ltd. ..... —
Agency—Tibbenham Publicity Ltd.

Harcourt, David, Ltd. ..... —
Agency—Allardyce Palmer Ltd.

Harpurhey Precision Engineers Ltd., The ..... —
Agency—Arthur Burns Publicity

Harris, John, Tools Ltd. ..... —
Agency—Sinclair Advertising Agency

Harvey, G. A., & Co. (London) Ltd. A50
Agency—G. P. Hughes Advertising

Hathernware Ltd. A93
Agency—Donald Macdonald (Adv.) Ltd.

Heap, Joshua, & Co. Ltd. ..... —

Heath Spring & Notion Co. Ltd., The ..... —
Agency—Tom C. Gough

Heenan & Froude Ltd. A19
Agency—Kenley Advertising Ltd.

Hermetic Rubber Co. Ltd. ..... —

Hilger & Watts Ltd. ..... —
Agency—Crane Publicity Ltd.

Hoffmann Mfg. Co. Ltd., The A31

Holden, Arthur, & Sons Ltd. A103
Agency—S. D. Toon & Heath Ltd.

Holroyd, John, & Co. Ltd. ..... —
Agency—C. R. Casson Ltd.

Horstmann Gear Co. Ltd., The A105
Agency—Trowbridge Pritchard & Co. Ltd.

Hughes, Geo. H., Ltd. ..... —
Agency—Elliott Advertising Ltd.

Hunt & Mitton Ltd. ..... —
Agency—Tom C. Gough & Partner Ltd.

Hygate, John, (Bath) Ltd. ..... —
Agency—Trowbridge Pritchard & Co. Ltd.

Hymatic Engineering Co. Ltd., The ..... —
Agency—London Press Exchange Ltd.

Ilford Ltd. 61
Agency—Samson Clark & Co. Ltd.

Imperial Chemical Industries Ltd. 85
Agency—Clifford Martin Ltd.

Impregnated Diamond Products Ltd. 43
Agency—E. Allan Cooper & Co. Ltd.

Index *(continued)*

Industrial Exhibitions Ltd. —
Agency—Commercial Publicity (London) Ltd.
Industrial Fan & Heater Co. Ltd. A1
Agency—Sinclair Advertising Agency
Infloid Manufacturing Co. Ltd. A104
Agency—W. Hopwood & Co.
International Combustion Products Ltd. Cover 1
Agency—Technical & General Adv. Agency Ltd.

Johnson Foster, H., Ltd. A101

Jayser, Ellison & Co. Ltd. A13
Agency—Stowe & Bowden Ltd.
Keelavite Rotary Pumps and Motors Ltd. —
Agency—Cogent Advertising Service Ltd.
Keeton, Sons & Co. Ltd. —
Agency—C. R. Casson Ltd.
Kendall & Gent Ltd. A54
Agency—Associated British Machine Tool Makers Ltd.
Kirkham, J. & W., Ltd. —
Klaxon Ltd Cover 3
Agency—C. Vernon Ltd.
Küppersbusch & Sohne AG. A80
Agency—Firma Albert Gebelhoff

Lang Pneumatic Ltd. —
Agency—J. Peers and Associates Ltd.
Lewis Spring Co. Ltd., The 171
Agency—Nicholls Dorrity Adv. Ltd.
Ley's Malleable Castings Co. Ltd. —
Agency—H. Raymond Morgan
Lincoln Electric Co. Ltd. A17
Agency—London Press Exchange Ltd.
Linread Ltd. A72
Agency—Beardmore Advertising Ltd.
Lloyd, F. H., & Co. Ltd. A49
Agency—Print for Industry Ltd.
Lodge Plugs Ltd. A80
Agency—Elliott Advertising Ltd.

Madan, Chas. S., & Co. Ltd. A55
Agency—Portland Advertising Ltd.
Magnetic Devices Ltd —
Agency—Arks Publicity Ltd.
Magnetic Valve Co. Ltd., The A39
Agency—Crane Publicity Ltd.
Measurement Ltd. —
Agency—Robert Brandon & Partners Ltd.
Metalifacture Ltd. A12
Agency—Rex Publicity Service Ltd.
Metropolitan-Vickers Electrical Co. Ltd. A14
Agency—Technical & General Advertising Agency Ltd.
Midland Industries Ltd. —
Agency—A. A. Black Ltd.
Minganti, Giuseppe, & Co. A16
Mining & Chemical Products Ltd. A45
Agency—John Mitchell & Partners Ltd.
Minnesota Mining & Mfg. Co. Ltd. —
Mirrlees, Bickerton & Day Ltd. A8
Agency—Rowlinson-Broughton
Monks & Crane Ltd. —
Agency—Sandbrook, Metcalf & Co. Ltd.
Moon Bros. Ltd. A56
Agency—Douglass & Co. Ltd.
Morgan Crucible Co. Ltd., The —
Morris, Herbert, Ltd. A82
Morris, B. O., Ltd. A29
Agency—Cogent Advertising Service Ltd.
Mountford, Frederick, (B'ham) Ltd. —
Agency—S. D. Toon & Heath Ltd.
Myford Engineering Co. Ltd. —

Napier, D., & Son Limited A2
Agency—C. R. Casson Ltd.
National Gas & Oil Engine Co. Ltd. A88
Agency—Rowlinson-Broughton Ltd.
Neill, James, & Co. (Sheffield) Ltd. A75
Agency—J. K. Clayton Adv. Agency Ltd.
Newage (Manchester) Ltd. A18
Agency—Howard Panton Ltd.
Newall, A. P., & Co. Ltd. A60
Agency—Osborne-Peacock Co. Ltd.
Newall Group Sales Ltd. —
Agency—J. Peers and Associates Ltd.
Newton, Chambers & Co. Ltd. —
Agency—Stanley D. Dickson
Nitralloy Ltd. A102
Agency—Stanley D. Dickson
North British Rubber Co. Ltd., The A52
Agency—The Robert Freeman Co. Ltd.

Osborn, Samuel, & Co. Ltd. —

Palmer, G. A. Stanley, Ltd. A100
Agency—Divers Advertising
Parmiter, Hope & Sugden Ltd. A97
Agency—Donald Macdonald (Advertising) Ltd.
Payne & Griffiths Ltd. A91
Agency—Sandbrook, Metcalf & Co. Ltd.
Pell, Oliver, Control Ltd. A30
Agency—S. C. Peacock Ltd.
Perry Barr Metal Co. Ltd. —
Agency—Tom C. Gough & Partners Ltd.
Pilkington Bros. Ltd. —
Agency—F. C. Pritchard Wood & Ptnrs. Ltd.
Pioneer Oilsealing & Moulding Co. Ltd. A23
Agency—Hyde & Partners Ltd.
Pitman, Sir Isaac, & Sons Ltd. A63
Positive Lock Washer Co. Ltd. A98
Agency—Peter A. Menzies Advertising
Precision Screw & Mfg. Co. Ltd., The —
Agency—Seal Advertising Service
P.R. Motors Ltd. —
Agency—A. A. Black Ltd.

Radio Heaters Ltd. A93
Agency—J. Peers & Associates Ltd.
Ransome & Marles Bearing Co. Ltd. —
Agency—Ruddocks Advertising Agency
Ransomes Sims & Jefferies Ltd. —
Agency—A.T.A. Advertising Ltd.
Rapid Magnetic Machines Ltd. —
Agency—Edward Hilton Advertising Ltd.
Ratcliffe, F. S. (Rochdale) Ltd. —
Agency—Osborne-Peacock Co. Ltd.
Rawsthorne's (Bolton) Ltd. A98
Revolvo Ltd. —
Agency—Ripley Preston & Co. Ltd.
Reynolds Tube Co. Ltd. A103
Agency—Ripley, Preston & Co. Ltd.
Richards, Charles, & Sons Ltd. A105
Agency—Longleys & Hoffmann Ltd.
Riley, Robert, Ltd. —
Agency—Commercial Advertising Service Ltd.
Rivlink Belts Ltd. —
Roberts, J. W., Ltd. —
Agency—Armstrong-Warden Ltd.
Robinson, L., & Co. (Gillingham) Ltd. A100
Agency—Ripley Preston & Co. Ltd.
Rocol Ltd. A22
Agency—Nevin D. Hirst (Advertising) Ltd.
Rotherham & Sons Ltd. A98
Agency—George Murray Advertising Ltd.

Salter, Geo., & Co. Ltd. —
Agency—Severn Publicity Ltd.
Sanderson Bros. & Newbould Ltd. A7
Sandiacre Screw Co. Ltd., The —
Agency—Bemrose Advertising Ltd.
Sandwell Casting Co., The —
Agency—Edward Hilton Advertising Ltd.
Saturn Industrial Gases Ltd. —
Agency—Crossley & Co. Ltd.
Savery, Thomas, Pumps Ltd. A51
Agency—Nicholls Dorrity Adv. Ltd.
Schrader's Son, A. A25
Agency—Godbolds Limited
Self-changing Gears Ltd. —
Selson Machine Tool Co. Ltd., The —
Agency—S. C. Peacock Ltd.
Sentinel (Shrewsbury) Ltd. —
Agency—J. Peers & Associates Ltd.
Serck Radiators Ltd. A9
Agency—Longleys & Hoffmann Ltd.
Sheffield Twist Drill & Steel Co. Ltd., The A83
Sherborne Rubber Co. Ltd., The A79
Agency—Sinclair Advertising Agency
Sintered Metal Components Ltd. —
Agency—Jack White and Associates
Smith, W. H., & Son Ltd. A78
Spa Plastics Ltd. —
Spear & Jackson Ltd. —
Agency—Oelrichs Advertising Ltd.
Spencer (Melksham) Ltd. A90
Agency—Trowbridge Pritchard & Co. Ltd.
Spencer Wire Co. Ltd. A102
Agency—Divers Advertising
Sperry Gyroscope Co. Ltd. A86
Agency—Samson Clark & Co. Ltd.

Standard Telephones & Cables Ltd. A37
Agency—Brockie Haslam & Co.
Star Foundry Ltd., The —
Agency—Tom C. Gough & Partners Ltd.
Steel, J. M., & Co. Ltd. —
Agency—Reynell & Son Ltd.
Stone-Chance Ltd. —
Agency—Notley Advertising Ltd.
Super Oil Seals & Gaskets Ltd. A64
Agency—A. A. Black Ltd.
Sykes, W. E., Ltd. A62
Agency—Warren Seymour & Co. Ltd.

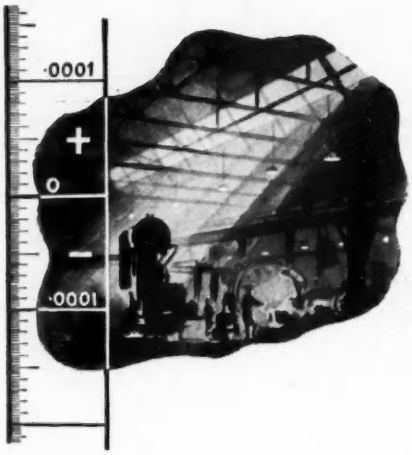
Tangyes Ltd. A67
Taylor, Taylor & Hobson Ltd. A41
Agency—Pitchfords Advertising Ltd.
Teddington Industrial Equipment Ltd. —
Agency—Crane's Publicity Ltd.
Terry, Herbert, & Sons Ltd. A40
Agency—John Haddon & Co. Ltd.
Thompson, John, Water Tube Boilers Ltd. —
Agency—Rowlinson-Broughton
Torrington Co. Ltd., The —
Agency—Osborne-Peacock Co. Ltd.
Tufnol Ltd. —
Agency—Crossley & Co. Ltd.
Turner Brothers Asbestos Co. Ltd. A58
Agency—Donald Macdonald (Advertising) Ltd.
Turner, Ernest, & Co. (Salford) Ltd. —
Tyre Products Ltd. —
Agency—Rylee (Advertising) Ltd.

Uni-Tubes Ltd. A24
Agency—Frederick Aldridge Ltd.
Universal Conveyor Co. Ltd. —
Agency—John Halifax Ltd.

Vaughan Crane Co. Ltd., The —
Vaughan, Edgar, & Co. Ltd. A26
Agency—Oldfield & Sharp
Ventilatorenfabrik Oelde G.M.B.H. A104
Vickers-Armstrongs (Engineers) Ltd. A108
Agency—Technical & General Adv. Agency Ltd.
Victor Products (Wallsend) Ltd. —
Agency—Doig Advertising Ltd.
Visco Engineering Co. Ltd. A91
Agency—Ernest Ingram Hill Ltd.
Vokes Ltd. A27
Agency—Crane Publicity Ltd.
Vulcascot (Gt. Britain) Ltd. A104

Wakefield-Dick Industrial Oils Ltd. —
Agency—Dorland Advertising Ltd.
Walker, Crosweller & Co. Ltd. A47
Agency—Beardmore Advertising Ltd.
Walker, M. W., & Staff Ltd. —
Agency—Alfred Bates & Son Ltd.
Walpamur Co. Ltd., The A95
Agency—Osborne-Peacock Co. Ltd.
Ward (Metal Details) Ltd. A6
Agency—Beardmore Advertising Ltd.
Ward, Thos. W., Ltd. A21
Agency—Oelrichs Advertising Ltd.
Weston, Chas., & Co. Ltd. —
Agency—Cross-Courtenay Ltd.
Westool Ltd. —
Agency—Tibbenham Publicity Ltd.
Whitehouse, Wm., & Co. Ltd. —
Agency—Severn Publicity Ltd.
Whittaker, Hall & Co. (1929) Ltd. —
Agency—Ingham Butterworth Ltd.
Whittle, T., & Sons Ltd. —
Agency—Baird & Dawson Ltd.
Whyte & Collins Ltd. A38
Agency—Sandbrook, Metcalf & Co. Ltd.
Wilcox, Edward, & Co. Ltd. A78
Agency—Donald Macdonald (Advertising) Ltd.
Wicksteed, Charles & Co. (1920) Ltd. A94
Agency—Nicholls, Dorrity Advertising Ltd.
Wolverhampton Die Casting Co. Ltd., The —
Agency—Sterling Advertising Ltd.
Wright, Bindley & Gell Ltd. A12
Agency—L. J. Fowler & Co. Ltd.
Wynstruments Ltd. —
Agency—Kenley Advertising Ltd.

Zinc Alloy Rust-Proofing Co. Ltd. A101
Zwicky Ltd. —
Agency—Richards & Thompson



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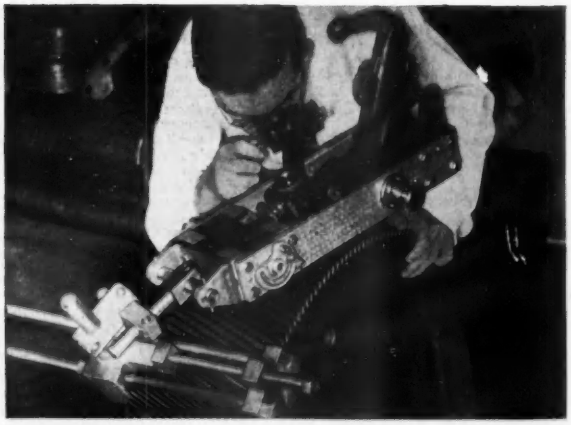

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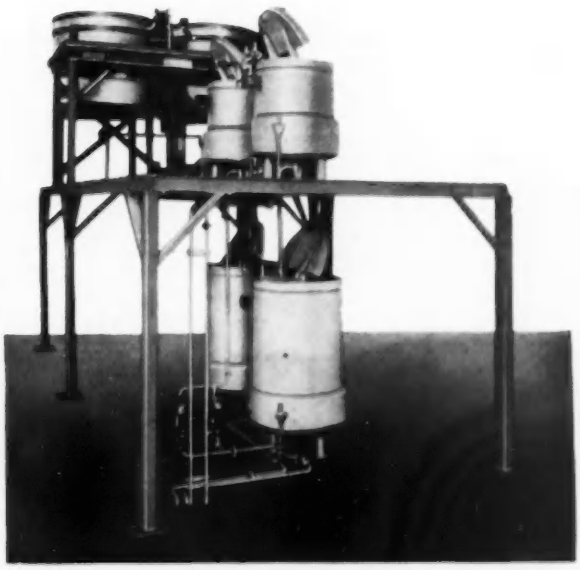

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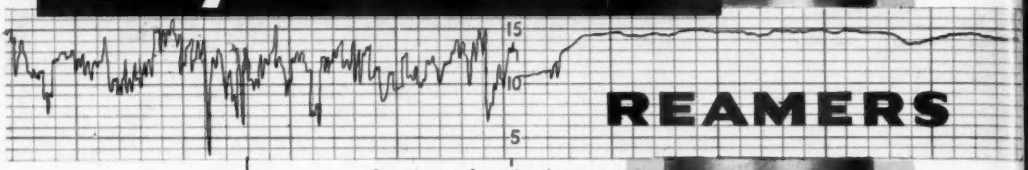

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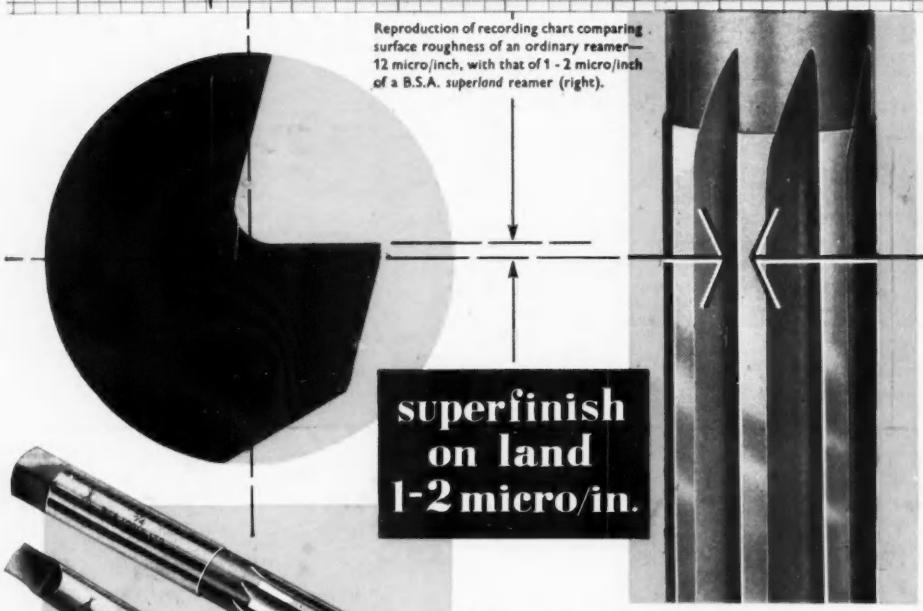

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